REPORT ON

WATER SUPPLY AND DISTRIBUTION

STORM AND SANITARY SEWER SYSTEMS,

FOR

LONGVIEW, WASHINGTON.

By
E. B. Black,
B.S. Civil Engineering, University of Kansas, 1909.

Submitted to the Department
of Civil Engineering and the
Faculty of the Graduate School
of the University of Kansas
in partial fulfillment of the
requirements for the degree of
Civil Engineer.

Approved by:

Instructor in Charge.

H. A. Rice

Head or Chairman of Department

May 4, 1924.

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WATER SUPPLY AND DISTRIBUTION,

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FOR

LONGVIEW, WASHINGTON

A THESIS SUBMITTED TO THE FACULTY OF

THE GRADUATE SCHOOL OF

THE UNIVERSITY OF KANSAS

FOR

THE DEGREE OF CIVIL ENGINEER

BY

E. B. BLACK

1924

FOREWORD

The following report dated May 28, 1923, on Water Supply and Distribution, Storm and Sanitary Sewers for Longview, Washington, and the supplemental report, Dated December 27, 1923, on sewage disposal, were prepared by me for the firm of Black & Veatch, Consulting Engineers, acting in the capacity of consulting engineers for the Long-Bell Lumber Company on all matters touching on water supply, storm and sanitary sewerage and sewage disposal for the new City of Longview. It is herewith submitted to the Faculty of the Graduate School of the University of Kansas as partial fulfillment of the requirements for granting the degree of Civil Engineer.

The City of Longview is located in Washington, at the confluence of the Columbia and Cowlitz Rivers. It occupies part of a 13,000 acre tract with six miles frontage on the Columbia and three miles on the Cowlitz River. Prior to the development undertaken by the Long-Bell Lumber Company, this tract was largely devoted to dairy, fruit and berry farms. The Long-Bell Lumber Company is here erecting a modern industrial city, with paved streets, water, storm and sanitary sewers. In what in 1922 was a loganberry patch, today stands one of the best appointed hotels on the coast. This is perhaps a less startling transformation than many of the physical changes effected on the townsite, which has been planned by Hare and Hare, landscape architects, in connection with the late George Kessler, City Planner.

Previously opportunity has never been given me to design utilities for a City being planned and built "from the ground up". The problems presented are perhaps more perplexing than those involved in a City already established. For example, there was in 1923 no basis for estimating the population necessary to serve at any specific time in the future. All calculations in the report, are, therefore, based on populations ranging from 15,000 to 75,000, by steps of 10,000 with the certainty today that the lower figure is too small and that under the circumstances which called Longview into existance, it is quite possible for the upper figure to be reached within the next twenty five years.

This report is not offered as the final "form" for engineering reports; it contains much data to be read and readily interpreted only by the client for whom it was prepared, because no attempt is made to explain conditions with which the client is familiar. However, it follows my usual practice in that the first ten pages contain the "meat" of my conclusions.

E. B. Black

Kansas City, Missouri.

May 4, 1924.

E. B. BLACK
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BLACK & VEATCH
CONSULTING ENGINEERS
MUTUAL BUILDING
KANSAS CITY, MO.

May 28, 1923.

The Long-Bell Lumber Company,
Kansas City, Missouri.

Gentlemen:

Pursuant to your instructions of December 23, 1922, we spent the month of January at Longview, Washington, studying the problems of water supply and distribution, sanitary sewer and storm sewer systems, and we present herewith our report covering these projects.

During the month at Longview, we designed the waterworks distribution system for that portion of the development lying between Douglass Street on the south, Ocean Beach Highway on the north, and Fowler Lake on the west, and prepared detailed estimates of pipe, fittings, valves and hydrants required for the construction of the part of the system necessary to serve, or to keep in advance of, that part of the development to be constructed this season.

We checked the general design of sanitary sewers, made such changes as were necessary in the size, grade and location of mains and laterals, and prepared the estimates of materials of those sewers necessary to serve this season's construction program. The entire storm sewer system was redesigned with respect to location, grade and size of sewers. The necessary adjustment of elevations of all storm and sanitary sewers, due to a final check of distances, or for interference with other sewers and pipe lines, was left to your Engineering Department.

After due consideration of a water supply from wells on Longview

Townsite, a supply from Coal Creek, filtered water from the Cowlitz River, and unfiltered water from a protected water shed on North and South Goble Creeks, we recommend the present development of the Goble Creek supply on the basis of a population of at least thirty five thousand. Goble Creek may be still further developed to provide for a population of seventy five thousand. Tabulations showing cost of development, operation, and cost per thousand gallons of water supplied at the estimated average rate of demand from the Cowlitz River and Goble Creek, follow on pages four, five and six, and the details of all the projects considered are discussed later in this report.

Surveys should be made this season on both North and South Goble Creeks to determine the location and capacity of impounding reservoirs to be located above the two dam sites tentatively selected by your Engineering Department. Location surveys, supplementing the preliminary surveys on which this report is based, should also be made for the flow line from Goble Creek to Longview Townsite, for it is likely the line can be considerably shortened, and construction cost and losses of heads reduced.

The water distribution system estimate of cost on page seven covers a design for a supply from Goble Creek, entering the townsite at the south east corner. Change to the Cowlitz River supply will allow a reduction in size of the 18" main on Seventh Avenue, from Hemlock Street to Douglass Street, and the 24" main in the alley between Fourteenth and Fifteenth Avenues from Hemlock Street to Douglass Street. These sizes will have to be determined after determination of the point of entry to the distribution system.

With respect to sanitary sewers we recommend that inasmuch as sewers require considerable time for construction, this program should be kept one season in advance of development of the town site. The Columbia River

Sanitary Sewage Pumping Station plans should be prepared and construction started at an early date, because it will probably be necessary after this season to discharge sanitary sewage into the Columbia River.

The question of providing West Kelso with sanitary sewers discharging into the Longview Sewer system, is a matter of policy which should be settled at an early date, in order not to hold back the construction of sewers into which West Kelso sewers will necessarily outlet. Estimates of cost of sanitary sewers follow on page eight.

It will be impossible to provide outlets for storm sewers until the proposed drainage ditch paralleling Third and Seventh Avenues from a point just south of Pennsylvania Street to Fowler Lake, is dredged, and until Fowler Lake is dredged to a point below the elevation of the storm sewers discharging into it. We recommend that sections of storm sewers be built in advance of paving or any other construction under which such sewers must pass. It will be understood that until proper outlets are provided by building the connecting links between construction so built and the outlets, that storm runoff will remain in portions of the sewers, inlets, and manholes. For this reason, the dredging of the drainage ditch and of Fowler Lake forms an important part of the storm sewer program. The storm sewers discharging to Fowler Lake can be provided with outlets, pending the dredging of the entire Lake, by dredging a ditch in the lake bed, between the sewer outlets and the lake overflow ditch. Estimates of cost of storm sewers are shown on page nine.

Longview, Washington

Comparative Costs of Cowlitz River and Goble Creek Water Supply Projects

Population	Filtered supply from Cowlitz River				Goble Creek Supply - Reservoir in Cascade Hills					
	Reservoir pressure		Direct pressure		Wood and cast iron pipe line		Cast iron pipe line		Concrete and cast iron pipe line	
	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head
Col. 1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7	Col.8	Col.9	Col.10	Col.11
	$	$	$	$	$	$	$	$	$	$
15,000	365,850	374,000	336,950	345,100	638,300	722,000	736,600	868,100	776,600	852,000
25,000	480,430	490,670	447,830	458,070	747,300	825,300	896,100	1,037,000	916,000	1,033,800
35,000	590,980	600,840	556,480	566,340	915,000	1,077,100	1,157,600	1,425,200	1,155,600	1,349,800
45,000	689,410	702,770	653,210	666,570	952,900	1,123,800	1,173,200	1,440,800	1,171,200	1,365,400
55,000	802,940	818,300	766,440	781,800	1,183,200	1,222,000	1,513,900	1,531,300	1,445,100	1,511,500
65,000	901,540	913,760	864,740	876,960	1,218,700	1,395,800	1,580,800	1,851,000	1,538,600	1,695,500
75,000	1,000,030	1,014,800	961,930	976,700	1,291,300	1,493,000	1,642,100	1,912,300	1,599,900	1,858,100

Black & Veatch

Longview, Washington

Comparative Annual Costs of Operation of Cowlitz River and Goble Creek Water Supply Projects

Population	Filtered supply from Cowlitz River				Goble Creek Supply - Reservoir in Cascade Hills					
	Reservoir pressure		Direct pressure		Wood and cast iron pipe line		Cast iron pipe line		Concrete and cast iron pipe line	
	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
	$	$	$	$	$	$	$	$	$	$
15,000	77,050	88,150	74,300	86,010	86,400	95,100	93,100	105,400	97,100	104,600
25,000	105,640	122,630	103,200	121,210	97,800	106,100	109,200	123,400	111,300	123,100
35,000	135,440	158,010	132,950	157,040	115,600	132,700	135,700	162,700	135,400	155,100
45,000	163,750	192,380	160,940	191,280	122,700	140,700	140,300	167,200	140,000	159,600
55,000	192,390	227,490	189,800	226,440	147,100	151,100	174,600	176,400	167,700	174,400
65,000	220,070	264,630	217,770	260,400	154,100	172,800	184,600	212,000	180,400	196,200
75,000	246,960	293,410	244,800	289,170	161,800	183,200	190,800	218,100	186,600	212,800

Black & Veatch

Longview, Washington

Cost per 1,000 Gallons of Water Supplied from the Cowlitz River and Goble Creek Water Supply Projects

Population	Filtered supply from Cowlitz River				Goble Creek Supply - Reservoir in Cascade Hills					
	Reservoir pressure		Direct Pressure		Wood and cast iron pipe line		Cast iron pipe line		Concrete and cast iron pipe line	
	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head	125' head	275' head
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11
	$	$	$	$	$	$	$	$	$	$
15,000	0.094	0.107	0.090	0.105	0.105	0.116	0.113	0.128	0.118	0.127
25,000	0.077	0.090	0.075	0.089	0.075	0.078	0.080	0.090	0.082	0.090
35,000	0.070	0.082	0.069	0.082	0.060	0.069	0.071	0.085	0.071	0.081
45,000	0.066	0.078	0.065	0.078	0.050	0.057	0.057	0.068	0.057	0.065
55,000	0.064	0.076	0.063	0.075	0.049	0.050	0.058	0.059	0.056	0.058
65,000	0.062	0.074	0.061	0.073	0.043	0.049	0.052	0.060	0.051	0.055
75,000	0.060	0.072	0.060	0.070	0.040	0.045	0.047	0.053	0.045	0.052

Black & Veatch

Longview, Washington

Estimates of Cost of Water Distribution System.

Estimate of Cost before grading Streets and Alleys:

46,645 lin. ft. 6" Class "C" C.I. pipe laid	@ $ 1.53	$ 71,366.85
44,400 " " 8" " " " " " "	2.13	94,572.00
8,050 " " 10" " " " " " "	2.79	22,459.50
18,465 " " 12" " " " " " "	3.60	66,474.00
5,880 " " 14" " " " " " "	4.35	25,578.00
2,300 " " 16" " " " " " "	5.38	12,374.00
4,210 " " 18" " " " " " "	6.37	26,817.70
6,610 " " 24" " " " " " "	9.98	65,967.80
123,000 pounds Standard special castings	0.07	8,610.00
221 Hydrants in place	90.00	19,890.00
279 - 6" double gate valves in place	33.15	9,248.85
47 - 8" " " " " "	51.82	2,435.54
11 -10" " " " " "	78.64	865.04
25 -12" " " " " "	99.25	2,481.25
7 -14" geared double gate valves without boxes	263.70	1,845.90
4 -16" " " " " "	318.83	1,275.32
5 -18" " " " " "	421.49	2,107.45
11 -24" " " " " "	650.75	7,158.25
		$ 441,527.45
15% to cover engineering and contingencies		66,229.11
	Total	$ 507,756.56

Estimate of Cost after grading Streets and Alleys:

46,645 lin. ft. 6" Class "C" C.I. pipe laid	@ $1.51	$ 70,433.95
44,400 " " 8" " " " " " "	2.08	92,352.00
8,050 " "10" " " " " " "	2.70	21,735.00
18,465 " "12" " " " " " "	3.50	64,627.50
5,880 " "14" " " " " " "	4.26	25,048.80
2,300 " "16" " " " " " "	5.38	12,374.00
4,210 " "18" " " " " " "	6.34	26,691.40
6,610 " "24" " " " " " "	9.83	64,976.30
123,000 pounds Standard special castings	0.07	8,610.00
221 Hydrants in place	90.00	19,890.00
279 - 6" double gate valves in place	33.15	9,248.85
47 - 8" " " " " "	51.82	2,435.54
11 -10" " " " " "	78.64	865.04
25 -12" " " " " "	99.25	2,481.25
7 -14" geared double gate valves without boxes	263.70	1,845.90
4 -16" " " " " "	318.83	1,275.32
5 -18" " " " " "	421.49	2,107.45
11 -24" " " " " "	650.75	7,158.25
		$ 434,156.55
15% to cover engineering and contingencies		65,123.48
	Total	$ 499,280.03

Longview, Washington

Estimates of Cost of Sanitary Sewer System

Estimate of Cost before grading Streets and Alleys:

18,900 lin. ft. 8" concrete pipe laid	@	$ 0.98	$ 18,522.00
68,928 " " 10" " " "		1.15	79,263.75
17,925 " " 12" " " "		1.70	30,472.50
5,035 " " 15" " " "		2.32	11,681.20
2,475 " " 18" " " "		2.91	7,202.25
3.700 " " 21" " " "		3.70	13,690.00
4,156 " " 24" " " "		4.02	16,707.12
1,320 " " 27" " " "		6.78	8,949.60
3,670 " " 30" " " "		7.95	29,176.50
1,300 " " 36" " " "		9.26	12,038.00
5,200 " " 42" " " "		11.25	58,500.00
93 Flushtanks in place		95.00	8,835.00
216 Manholes in place		65.00	14,040.00
3,000 lin. ft. 3/4" G.I pipe laid		0.50	1,500.00
			$ 310,577.92
15% for engineering and contingencies			46,586.68
	Total		$ 367,164.60

Estimate of Cost after grading Streets and Alleys:

18,900 lin. ft. 8" concrete pipe laid	@	$ 0.91	$ 17,199.00
68,928 " " 10" " " "		1.18	81,335.04
17,925 " " 12" " " "		1.72	31,906.50
5,035 " " 15" " " "		1.96	9,868.60
2,475 " " 18" " " "		2.68	6,633.00
3,700 " " 21" " " "		3.32	12,284.00
4,156 " " 24" " " "		3.94	16,374.64
1,320 " " 27" " " "		6.80	8,976.00
3,670 " " 30" " " "		7.85	28,809.50
1,300 " " 36" " " "		9.26	12,038.00
5,200 " " 42" " " "		11.25	58,500.00
93 Flushtanks in place		95.00	8,835.00
216 Manholes in place		65.00	14,040.00
3,000 lin. ft. 3/4" G.I. pipe laid		0.50	1,500.00
			$ 308,299.28
15% for engineering and contingencies			46,244.89
	Total		$ 354,544.17

Longview, Washington

Estimates of Cost of Storm Sewer Systems

Estimate of Cost before grading Streets and Alleys:

4,470 lin. ft. 12" concrete pipe laid	@	$ 1.48	$ 6,615.60
17,200 " " 12" concrete inlet pipe laid		1.26	21,672.00
4,970 " " 15" " pipe laid		1.86	9,244.20
6,795 " " 18" " " "		2.32	15,764.40
5,025 " " 21" " " "		2.72	13,668.00
5,570 " " 24" " " "		3.55	19,773.50
3,730 " " 27" " " "		6.36	23,722.80
6,750 " " 30" " " "		6.43	43,402.50
5,280 " " 36" " " "		9.13	48,206.40
3,200 " " 42" " " "		8.77	28,064.00
6,550 " " 48" " " "		14.09	92,289.50
1,700 " " 54" " " "		15.55	26,435.00
405 Standard inlets, in place		40.00	16,200.00
149 " Manholes, in place		60.00	8,940.00
			$ 373,997.90
15% to cover engineering and contingencies			56,099.68
		Total	$ 430,097.58

Estimate of Cost after grading Streets and Alleys:

4,470 lin. ft. 12" concrete pipe laid	@	$ 1.34	$ 5,989.80
17,200 " " 12" concrete inlet pipe laid		1.26	21,672.00
4,970 " " 15" " pipe laid		1.77	8,796.90
6,795 " " 18" " " "		2.27	15,424.65
5,025 " " 21" " " "		2.57	12,914.25
5,570 " " 24" " " "		3.29	18,325.30
3,730 " " 27" " " "		3.74	13,950.20
6,750 " " 30" " " "		6.18	41,715.00
5,280 " " 36" " " "		8.74	46,147.20
3,200 " " 42" " " "		8.74	27,968.00
6,550 " " 48" " " "		11.32	74,146.00
1,700 " " 54" " " "		15.51	26,367.00
405 Standard inlets, in place		40.00	16,200.00
149 " Manholes, in place		60.00	8,940.00
			$ 338,556.30
15% to cover engineering and contingencies			50,783.44
		Total	$ 389,339.74

Following this brief summary of our conclusions and recommendations, are details of the various problems considered, compilations to support the tabulations and estimates presented, and exhibits covering part of the preliminary data used in the preparation of the report. The text of specifications covering the water distribution system and sanitary sewers, is also given herewith.

We have considered it unnecessary to put into this report many details supporting some of the summaries presented, but all such data is available if you need it in explanation of any part of the text or tabulations presented herewith.

Throughout our field investigation at Longview, we received the hearty cooperation of not only the Engineering Department, but also of all those in the Long-Bell organization from whom we requested information, and we wish to acknowledge our appreciation of the assistance and courtesies extended us.

Respectfully submitted,

BLACK & VEATCH

By E. B. Black
(E. B. Black)

Longview, Washington

Water supply and distribution.

Four sources of water supply have been considered in arriving at our conclusions and recommendations as set forth on the first pages of this report, viz.:

(1) Deep wells on Longview Townsite

(2) Impounded supply on Coal Creek

(3) Filtered supply from the Cowlitz River

(4) Impounded supply on the North and South forks of Goble Creek

In the consideration, and the elimination of all but the Goble Creek supply, we have developed, just as far as is possible from the preliminary surveys and other data available, the comparative costs of construction, operation, the cost per thousand gallons of water supplied, and have given due consideration to these items in arriving at our conclusions.

After an inspection of portions of the Coal Creek drainage area and of one possible location for a dam site on that area, we have eliminated it from consideration. Practically the entire drainage area of Coal Creek above the dam site has been logged off, and in our opinion the water from such an area would require treatment at the site of the impounding reservoir prior to being introduced to the flow line leading to Longview. The drainage area above the dam site covers approximately twelve square miles, an area approximately sixty three (63) per cent of the North and South Goble Creek drainage area, and too small to supply the quantity of water ultimately needed for Longview. There is but one suitable reservoir site, and a dam at this point would be approximately fifteen hundred (1,500) feet in length.

The elevation of the Coal Creek dam would allow a gravity flow to Longview townsite, with reservoirs at the same elevations considered in the Goble Creek project. The Coal Creek pipe line would be approximately 50,000 feet long as compared to 81,000 feet of branch and main line required in developing the Goble Creek supply; the Cowlitz River crossing would be eliminated. Detailed surveys are necessary before a report can be made of the cost of the Coal Creek project, but it is our opinion that the character and limited area of the water shed, eliminates this project from consideration.

Our reasons for eliminating a supply from wells, other than their use as a supply during the two or more seasons necessary for developing a permanent supply, are discussed in the following pages.

Careful consideration of the tabulations of cost of construction, operation, and cost per thousand gallons of water supplied, on pages four, five and six, shows that while the initial cost of the Goble Creek development is greater in all cases than that of the Cowlitz River supply, owing to the less cost of operation of the Goble Creek supply, the cost per thousand gallons is less for all populations over fifteen thousand. The cost of water to the consumer is an important matter, but the sources of supply and the quality of the water supplied may far outweigh the question of cost.

It is our opinion that the success or failure of the Longview project depends largely on the quality of water supplied. The growth of the Townsite and increase of population beyond the number necessary to care for Long-Bell interests, brings Longview in direct competition with other Cities and Towns in that section, many of which take their supply from impounding reservoirs supplied by snow fed mountain streams. The mental attitude of a city's population toward a water supply, depends largely on its experience with water supplied, and in a section where such a supply as the one from Goble Creek can be had at an equal or less cost per thousand gallons than a filtered supply from the Cowlitz River, there is little doubt as to which will be the popular supply.

Studies have been made of the effect on original cost and operation of the Cowlitz River and Goble Creek water supply projects, with the water plane in Longview at elevations one hundred twenty five (125) and two hundred seventy five (275), and of the further effect of operating "closed" and "open" systems at these heads. The purpose of these studies, with respect to differences of head, was to determine if operating costs, in the case of the Cowlitz River supply, and construction and operating costs in the case of the Goble Creek Supply, could be sufficiently reduced by normal operation of the system at a hundred and twenty five foot head, to justify operation of engines to boost pressure for fire fighting.

With no demand on the distribution system, water pressures at the Civic Center will approximate forty three (43) pounds and one hundred and eight (108) pounds, when the water plane is at elevation one hundred twenty five (125) and two hundred seventy five (275) respectively. With the lower pressure, as it will be decreased by the demand when fighting fire, engines will at times be required for increasing the pressure so effective fire streams may be developed. With the one hundred eight (108) pound pressure, there will be at all times a sufficient pressure for fire fighting without the use of engines.

The following tabulation calculated from the tabulations on pages four, five, and six, shows the difference in investment, annual operating cost, and cost per thousand gallons of water supplied, at one hundred twenty five (125) foot and two hundred seventy five (275) foot elevations, for populations of fifteen, thirty five, forty five, and seventy five thousand. In all cases this difference appears as a saving in favor of the lesser head. In this tabulation no account is taken of the investment in engine equipment, its housing, and extra cost of operation over the operating cost of fire station equipment using pressure direct from the mains.

Population	Cowlitz River		Goble Creek		
	Reservoir pressure	Direct pressure	Wood pipe line	Cast iron pipe line	Concrete pipe line
	Saving in investment by use of 125 foot elevation.				
15,000	$ 8,150	$ 8,150	$ 83,700	$131,500	$ 75,400
35,000	9,860	9,860	162,100	267,600	194,200
45,000	13,360	13,360	170,900	267,600	194,200
75,000	14,770	14,770	201,700	270,200	258,200
	Saving in annual operating costs by use of 125 foot elevation.				
15,000	$11,100	$11,710	$ 8,700	$ 12,300	$ 7,500
35,000	22,570	24,090	17,100	27,000	19,700
45,000	28,630	30,340	18,000	26,900	19,600
75,000	46,450	44,370	21,400	27,300	26,200
	Saving in cost per 1,000 gallons of water supplied.				
15,000	$ 0.013	$ 0.015	$ 0.011	$ 0.015	$ 0.009
35,000	0.012	0.013	0.009	0.014	0.010
45,000	0.012	0.013	0.007	0.011	0.008
75,000	0.012	0.010	0.005	0.006	0.007

Should the Cowlitz River project be selected, the saving in original investment and operating cost will not justify the use of engines until a population of 25,000 is reached. In the case of a gravity supply from

Goble Creek, the saving in investment, operation, and cost per thousand gallons of water supplied, shows that the economical plan is to build the Cascade Hills reservoir at approximately elevation one hundred twenty five (125) and to use engines when necessary to increase pressures for fighting fire.

There is a practical consideration involved in choosing between engines and a sufficient main pressure for fire fighting, and that is the maintenance cost, hose included, of engine equipment. This has been taken into account before making the final statement in the preceding paragraph.

A forty three (43) pound pressure at the ground floor of buildings as high as the Monticello Hotel, will result in low water pressures on the upper floors at time of peak demand on the distribution system. These periods will come each day in the case of normal demand, and will be from thirty minutes to two hours in length, with a possible total daily peak period of three hours. It is certain that provision will have to be made to boost pressures for this building, but the expense of operating special pumps within the building, should not be the controlling factor in the selection of the water plans elevation.

The comparisons of "closed" and "open" systems apply only to the Cowlitz River supply; in the "closed" system pressure is applied to the distribution system directly by the pumps; the "open" system operates with a storage reservoir between the pumps and the distribution system. In the case of the direct pressure or closed system, the connection between the filter plant and the distribution system would be a pipe line laid directly between the pumping plant and some point in the distributing system near the north east corner of the townsite. The plant would operate to hold the water plane at either elevation one hundred twenty five (125), two hundred seventy five (275), or any intermediate point which might prove desirable. Direct pressure systems usually operate at about 40 pounds pressure, increasing the pressure when necessary for fire fighting. In such systems it is necessary to use pumping equipment providing for fluctuations in rate of demand, and operation of the system is probably more complicated than the open, or reservoir system, because of this fact.

In the case of the open, or reservoir pressure system, as it is indicated in the tabulations, the water is pumped at a fixed rate from the clear well to a reservoir connected directly to the distribution system. Fluctuations in demand are taken by the reservoir instead of by the clear well and pumping equipment. In the reservoir system it is possible to arrange to by-pass the reservoir, should higher pressure be needed for fire fighting, and furnish pressure direct from the pumps at the filter plant. No figures have been prepared on this basis. The additional cost will be cost of fire pumps, a short section of pipe line, and automatically controlled valves for by-passing the reservoir.

The following tabulation taken from pages four, five, and six, of this report shows the difference in construction cost, operating cost, and the cost per thousand gallons between the "open" and "closed" systems for populations of fifteen, thirty five, forty five and seventy five thousand.

In all cases the tabulation represents a saving of the "closed" over the "open" system. The "open" system, however, is a better operating proposition, less liable to dangerous break downs and lends itself more readily to development of the townsite west of Fowler Lake, than does the "closed" system.

Population	Cowlitz River Supply — Saving of direct pressure or "closed" system over reservoir pressure or "open" system water plane at elevation 125	elevation 275
	Original investment	
15,000	$ 28,900	$ 28,900
35,000	34,500	34,500
45,000	36,200	36,200
75,000	38,100	38,100
	Annual operating cost	
15,000	$ 2,750	$ 2,140
35,000	2,490	970
45,000	2,810	1,100
75,000	2,160	4,240
	Saving per 1,000 gallons of water furnished	
15,000	$ 0.004	$ 0.002
35,000	0.001	0.000
45,000	0.001	0.000
75,000	0.000	0.002

Your Engineering Department at Longview, has based their calculations for necessary water supply on an average per capita per day rate of 150 gallons, and we fully agree with this estimate. In the design of supply works we are required by the National Board of Fire Underwriters to design on the basis of the maximum daily rate, which occurs for a period of a few days each year, and until experience has in each case established a definite maximum, is taken as one and one half times the average daily rate. We are also required to provide a fire fighting supply in gallons per minute, for a ten hour period, based on the formula $G = 1{,}020\sqrt{P}\ (10.01\sqrt{P})$, in which "G" equals gallons per minute and "P" equals population in thousands.

Except as deficiencies are discussed in detail under specific items, all calculations accompanying this report, capacity of works, pumping equipment, flow lines and other items having to do with rates of supply, have been based on the maximum daily rate, column (3), in the following tabulation. Costs per thousand gallons are without exception based on column (2), the average daily rate. Capacities of clear wells, and storage reservoirs, provide for the National Board of Fire Underwriters fire flow requirements in column (5), excepting as noted later in this report.

Population	Average daily supply at 150 gallons per capita.	Max. daily supply, 150% of Col. (2)	Gallons per minute fire flow	Total 10 hour fire flow
(1)	*(2)	*(3)	(4)	*(5)
15,000	2.25	3.38	3,800	2.28
25,000	3.75	5.63	4,900	2.94
35,000	5.25	7.88	5,700	3.42
45,000	6.75	10.13	6,400	3.84
55,000	8.25	12.38	7,000	4.20
65,000	9.75	14.63	7,600	4.56
75,000	11.25	16.88	8,100	4.86

* Millions of gallons.

Water supply and distribution.
Wells:

A considerable amount of test work has been carried on in putting down deep wells for a temporary supply on the townsite. The Engineering Department at Longview is in touch with and fully advised respecting the results of these tests. There is little question but wells on the townsite are fed by underground waters, either from the Cowlitz or Columbia Rivers, or both.

On the townsite area are such structures as Coffin Rock, Mt. Solo, and other isolated rock islands or ledges of considerable extent projecting above the surface of the valley. Such formations and their locations indicate that so far as unbroken underground flows in the valley of the Cowlitz and Columbia are concerned, wells in the northern and western part of the townsite run the risk of being either isolated or tapping broken water bearing strata. In either case such wells would be easily exhausted if pumped at a rate necessary to provide a supply of considerable quantity. The locations of rock dams and dikes similar to those appearing above the surface, but not showing above the surface, are not known and they may be encountered anywhere over the area north and west of a line drawn approximately from West Kelso to Mt. Solo. Wells south and east of this line get their supply from gravel which probably covers a considerable area between the Cowlitz and Columbia Rivers, and draws its supply from both of them. Wells over the entire townsite area are still further condemned because of hardness, and because of the difficulty of keeping them free from pollution.

Laboratory analyses and inspection of samples from Well No. 1, located between 18th and 19th Avenues at Baltimore Street, shows that untreated well water will not be suitable for domestic consumption and for manufacturing use; neither will it be a good boiler water. Such water should be softened, and its iron content would probably make it necessary to remove the iron in addition to softening; an iron removal and softening plant may be just as successfully operated as a filtration plant for the treating of a supply from the Cowlitz River, but the location of the wells to furnish the supply necessary, would require unusual precautions for safe guarding them from surface pollution, and in our opinion, the supply would not be so satisfactory as a supply from the Cowlitz River. The cost of construction, operation, and cost per thousand gallons of the water will approximate the Cowlitz River supply, settling and grit basins being the only item of construction on which a saving would be effected.

There is always considerable conjecture with respect to the source of supply of a well water, but in the case of the wells on Longview townsite, especially in the case of Well No. 1, it seems there can be no doubt but this supply comes from the Columbia or the Cowlitz Rivers. During January, the winter rise in the Columbia and Cowlitz Rivers occurred and Well No. 1 started to flow. During a part of the flood period readings were taken on the well and on the Columbia and Cowlitz River gauges, and the chart on page sixty eight (68) shows the results of these readings. Inasmuch as Well No. 1 was in use during the flood period, it was impossible to remove the pump and determine the level to which the water in the well would rise in a section of casing raised above the surface.

The fact the well started to flow after the rise in the Columbia and Cowlitz Rivers, and continued flowing for a period of time after the rivers has lowered below the water elevation in the well, may be urged as an indication that the supply was from either river. This theory is not in accordance with facts developed by your Engineering Department from experiments with river infiltration at the townsite. Those experiments demonstrated that the rise of ground water in test wells on the townsite followed the rise of the Columbia River after an interval and showed a greater elevation than the Columbia River, from which the test wells drew their supply, for a period after the flood has subsided. This is demonstrated by curves shown on sheet sixty nine (69).

It will be necessary to use a water supply from wells during the period of construction of permanent supply works; with proper supervision, including testing of the well water at stated intervals of not less than one month, and the installation of chlorinating apparatus for sterilizing the water in the event patheogenic organisms are discovered, no ill effects should be experienced from its use. We do not, however, recommend the use of wells as a part of the permanent supply for the city, excepting as they may be retained for an auxiliary or emergency supply.

Water supply and distribution.
Cowlitz River:

The Cowlitz River is a possible source of supply which must be given due weight. This river and its tributaries, the Toutle River being the principal tributary, have an extensive drainage area to the north and east of Longview. The Cowlitz River heads to the south and east of Mount Rainier, and the entire runoff comes from snow and rainfall on the mountains. There can be no question of quantity. United States Geological survey gaugings of the Cowlitz and its tributaries are not complete over an extended period, but a record is available of the gaugings of the Cowlitz, near Mayfield, for the ten month period ended September 30, 1911, and of the Toutle River near Castle Rock, for the year ended September 30, 1911. For these periods the run off in millions of gallons daily, was as follows, the last six figures being omitted in each case.

	Toutle River at Castle Rock	Cowlitz River near Mayfield	Total
Millions of gallons daily, on basis of yearly mean	1,095	3,297	4,392
Millions of gallons daily, on basis of monthly minimum	225	1,231	1,486

Inasmuch as the drainage area of the Cowlitz River above Mayfield is only 1,300 square miles, the run off from a considerable drainage area, below Mayfield and above Longview, is not accounted for in the above figures.

In the event it is decided to use a filtered supply from the Cowlitz River, our plan would be to locate the river intake, low service pumping station, grit basins, settling basins, filtration plant and high service pumping station, half to three quarters of a mile up River from West Kelso, at a point where ample space may be secured for extensions and additions to the plant, and where it could be well protected from flood. The low service pumping station would take water from a permanent concrete intake in the River, and would pump to grit basins built as a part of the settling basins. From these basins the water would pass through concrete, gravity type, rapid sand filters to a clear water well. The filters would be built with a normal operating capacity equal to the maximum daily demand of one and one half times the average daily consumption. The clear well capacity depends on whether or not a closed or open system of distribution is adopted. Column three, page forty-two (42) shows the required capacity of the clear well for a closed system; the size of clear well in this case is figured on the basis of ten hours normal demand plus a ten hour fire flow with allowance for ten hours filter capacity. In the case of the open system, the clear well serves to take up fluctuations of operation in the filters, and variation in pumpage rates; and the Cascade Hills storage reservoir in this case has been figured at the same capacity as the clear well in the closed system.

There can be no question but Cowlitz River water, treated by a modern water purification plant, will be safe and of quality suitable for both domestic and manufacturing purposes. However, Cowlitz River water is not an ideal water to treat. A part of the territory through which it flows has been logged off, and logging operations will continue on the Cowlitz River and its tributaries for years to come. Flood runoff from logged off drainage area is precipitious, and at flood periods tremendous quantities of suspended material are carried along either in suspension or in collodial solution in the Cowlitz River at Longview. This means that in the design of a filter plant to filter this water, extra precaution must be used in the study of the problem and in the design of the plant, to insure adequate settling basin and filter capacity to handle the raw water in all stages of turbidity.

Water is not at all times rendered safe by filtration alone; under normal conditions a well operated filter plant will remove approximately 99% of the bacteria; but all water to be used as a public water supply, after being filtered must be chlorinated or otherwise treated to render harmless the bacteria remaining therein. There are a number of methods of sterilizing clear filtered water, the most common of which is by means of liquid chlorine, supplied through either manually operated or automatic equipment, proportioning the amount of chlorine to the rate of flow of water. There is also in use in plants where the cost of electric energy is not excessive, a method of sterilizing by use of ultra violet rays. This method consists of circulating clear water about lamps generating ultra violet rays. The method is better known for sterilizing water for swimming pools than it is for large supplies, probably because of the cost of treatment where energy costs are high, but the results are certain and satisfactory, and this method is now being used on supplies up to 3,000,000 gallons per day.

The low service and high service pumping plants in connection with the filter plants, for both open and closed systems, have been figured on the same capacity basis as the filters, the maximum daily rate. In all cases modern motor driven pumps have been used and the costs of operation of low and high service pumping equipment are duly set forth elsewhere in this report.

Comparative analyses of cost of electric and steam pumping have not been made. Our opinion is that it would be as economical to operate by electricity generated at the Company's own power plant on the mill site or elsewhere, than it would be to operate steam turbine driven pumps at the filter plant. Whatever advantage steam driven pumps may have over motor driven pumps, is lost in this case, because their use would make it necessary to build at the filter plant a steam generating plant for the low and high service pumps.

The Cascade Hills reservoir to be used in connection with the "open" pressure system, has been estimated on the basis of a reinforced concrete reservoir, with a fifteen foot depth of water, and covered with a concrete roof. The capacity for various populations is shown on page forty-two. This reservoir is of less capacity than the Cascade Hills reservoir at the same location, for the Goble Creek supply, because of the necessity for greater storage when supplied by pipe line of considerable length.

Water supply and distribution.
North and South Goble Creeks:

In 1922 your Engineering Department made preliminary location surveys for dams to create impounding reservoirs on both North and South Goble Creeks. Surveys were also made of the reservoir sites above the dams, of the flow line locations from the dams to a junction point near the confluence of the two Creeks. From this hunction preliminary surveys for a flow line were run over the route indicated by the map on page seventy-three. All of the estimates of quantities and costs accompanying this report, are based on these preliminary surveys, and it is our recommendation that sufficient additional surveys be made this season, to definitely fix the location of the flow line prior to its design, and that further reservoir sites, above the sites surveyed last season, be surveyed now. The development of the Goble Creek project so far as the building of dams is concerned, may be accomplished by stages, and since the type of dam construction recommended by your Engineering Department, and concurred in by us, is the hydraulic fill type, it will be desirable to build up stream dams first. In addition to that fact, it is essential that the impounding reservoir possibilities of both North and South Goble Creeks be fully surveyed and reservoir capacities approximately determined prior to starting the development of the projedt.

We have no doubt but the Goble Creek drainage area under consideration and as shown on the map on page seventy-three (73), will furnish a sufficient supply for an average City having a population of seventy five thousand. If in the future it becomes necessary to provide for a greater population than seventy five thousand, due to the needs of Longview and environs, additional supply may be developed from drainage areas on either side of the Coweman River and conveyed to Longview by gravity.

The runoff from the Goble Creek drainage area, and the possibility of creating impounding reservoirs of sufficient capacity to make up deficiencies of runoff at certain seasons of the year, are questions on which the adequacy of the Goble Creek project depend. In June of 1922 your Engineering Department started making daily gaugings of both North and South Goble Creeks, and a record of rainfall, at the Schrier Ranch. The record does not cover a sufficient length of time to form an accurate estimate of the seasonal variation of discharge from the two Creeks, but it does give the best record available of the discharge through a dry summer. The rainfall gaugings at the Schrier Ranch probably do not represent the average for the drainage area, but they have a more direct bearing than gaugings at more distant stations. The following tabulation is compiled from data supplied by your Engineering Department, and shows rainfall and runoff for the period from June 3, to December 8, 1922.

Period	Rainfall		Runoff, Millions of Gallons		
	Inches	Millions of Gallons	North Goble	South Goble	Total
1922					
June 3-30	0	0	110	152	262
July	0	0	35	84	119
August	2.66	898	57	133	190
September	4.21	1,422	115	234	349
October	6.00	2,027	163	267	430
November	3.54	1,195	268	327	595
December 1-8	5.50	1,858	136	142	278
	21.91	7,400	884	1,339	2,223

It will be noted that no rain fell in June or July of the above period, but the total runoff for the two months was 381 million gallons, while the total runoff for the four month period from June 3, to September 30, was 920 million gallons. Rainfall records over a period of twenty three years for Astoria, Castle Rock, Kalama, Olympia, Portland, Rainer, Seattle, and Vancouver, (the record for Castle Rock, Kalama and Rainier being for portions of the period only), shows that June and July of 1922 were unusually dry months. No rainfall in July was recorded by any of the above Cities, Portland alone reporting a trace.

The summary of average, maximum, and minimum precipitation in the above Cities, page sixty-five, for the twenty three year period, shows that the minimum rainfall for the twenty three years has occurred in the months of June, July, August and September, however, the average rainfall for all the Cities listed, for the above months, is 1.89, 0.75, 0.98, and 2.72 inches respectively.

Taking into consideration all of the above data, we feel safe in assuming the minimum monthly flow recorded in 1922, as the basis for calculating capacities of the Goble Creek reservoirs. The following table shows the supply required for three and four month periods, and the reservoir capacities required to supply the deficiency of a monthly minimum flow of 119 million gallons, for the populations indicated.

Population	Supply required for		Reservoir capacities required for	
	3 months	4 months	3 months	4 months
15,000	211	278	(e) 146	(e) 198
25,000	350	462	(e) 7	(e) 14
35,000	489	647	(rc) 152	(rc) 197
45,000	628	831	(rc) 312	(rc) 409
55,000	767	1,015	(rc) 473	(rc) 620
65,000	907	1,199	(rc) 632	(rc) 831
75,000	1046	1,383	(rc) 793	(rc) 1,043

(e) - Excess of runoff over supply required.
(rc) - Reservoir capacity required to supply deficiency of flow, allowing 15% of capacity for seepage and evaporation.

Preliminary surveys by your Engineering Department show that two impounding reservoirs , located on North and South Goble Creeks, will store 494 million gallons. There should be no difficulty in developing additional reservoirs above the two now tentatively located, to supply the storage called for by the above tabulation. During the period from June 3, to December 8, 1922, North Goble Creek gaugings showed an average of thirty eight per cent of the total runoff from the two Creeks. In July the per cent of total was twenty nine (29) and from December 1 to 8, forty nine (49), These figures indicate the necessity of making further runoff gaugings over an extended period, and rainfall gaugings, preferably on the drainage areas, in addition to those at the Schrier Ranch. This information is necessary in determining the relative capacity of reservoirs on the two Creeks.

In our opinion, reservoir capacity should be estimated on the basis of a four month period.

Aside from the rainfall gaugings made at the Schrier Ranch, no rainfall data is available for the Goble Creek Area. U. S. Geological Survey Water Supply Paper 312, presents the results of rainfall and runoff observations over large areas in the Northwest in the form of two maps, on one of which is indicated the average annual precipitation in inches and on the other the average annual run-off in inches. From these maps the Goble Creek area is given a mean annual precipitation of 50 inches while the average runoff is given as 20 inches, or an annual average runoff of 40 per cent. These maps cannot have other than general application to the Goble Creek area. A forty per cent runoff of the average annual rainfall is not an excessive runoff for such a drainage area. One inch runoff from this area, estimated as nineteen square miles above dam sites, is equivalent to 330 million gallons, and an annual rainfall of thirty one and a half (31.5) inches, with a forty (40) per cent runoff, is sufficient to supply a population of 75,000.

In operation, water from reservoirs on North and South Goble Creeks will be conveyed by gravity pipe line to an equalizing reservoir located near the confluence of the two creeks. This reservoir will be small, and is necessary only to equalize difference in elevation between the two sources of supply. From the equalizing reservoir a single flow line will follow the route marked on the map, or such later location as may be determined, to a point marked "Owl Creek Reservoir Site". At this point the flow line will change to a pressure line, connecting with the distribution system at Longview townsite near Fourteenth Avenue and Douglass Street. Leaving the distribution system at the intersection of the alley between Sixteenth and Seventeenth Avenues, and the alley south of Ocean Beach Highway, the line will be extended to the Cascade Hills reservoir at elevation one hundred twenty five (125) or two hundred seventy five (275). In all calculations with respect to wood or concrete pipe lines, that portion of the line between Owl Creek reservoir site and the distribution system, is of Class "C" cast iron pipe. Lighter than Class "C" can be used for a part of this line, but we have considered it necessary to use neither wood pipe nor concrete pipe between the distribution system and the Owl Creek reservoir site.

When we were in Washington it appeared that it would be advisable to build a storage reservoir at Owl Creek,but after a consultation with the engineers from the National Board of Fire Underwriters,we decided that the expense was not warranted, so a reservoir at this site has not been included in any of our estimates.

The Cowlitz River crossing for the flow line has been estimated on the basis of a concrete lined tunnel approximately one hundred and fifty feet below ground surface, and of sufficient size to carry two twenty-four inch (24") cast iron pipe lines. We do not consider it advisable to attempt this River crossing without the use of such a tunnel, and the length and depth of the tunnel are subject to detailed field surveys to be made later.

In all cases the flow line from Goble Creek to the Cascade Hills reservoir has been calculated for the maximum daily domestic consumption of one and one half times the assumed average daily consumption. The Cascade Hills reservoir has been figured as an open concrete reservoir with a capacity of seventy per cent (70%) of the National Board of Fire Underwriters' requirements, based on one hundred per cent (100%) being a capacity equivalent to one day's maximum consumption plus a ten hour fire flow. The capacity used in our estimates are as follows:

Population	Reservoir Capacity millions of gallons
15,000	4.0
25,000	6.0
35,000	8.0
45,000	10.0
55,000	11.6
65,000	13.4
75,000	15.2

It will be recalled that we required a roofed over reservoir for a filtered supply from the Cowlitz River. We required this because in our opinion there is more danger of algae growths occurring in the filtered water than in the Goble Creek supply, however, the details of construction of the reservoir for a Goble Creek supply should provide for roofing later if it proves desirable.

In estimating cost of wood pipe lines we have used a life expentancy of ten (10) years. Sinking fund calculations on installations involving use of wood pipe provide for replacing the wood pipe portion of the flow line every ten years.

The cost of cast iron pipe and concrete pipe flow lines are influenced considerably by reason of the fact that this pipe is manufactured only in certain sizes. For example, cast iron pipe goes from twenty inches in diameter to twenty four inches, and then to thirty inches. A considerable saving may be effected in the concrete pipe flow lines if the concrete pipe companies will manufacture pipe to the sizes required by our calculations instead of the sizes normally manufactured for the trade.

Water supply and distribution.
Distribution System:

The distribution system as planned while we were in Washington in January covers the townsite as bounded by Fowler Lake on the south and west, and Ocean Beach Highway on the north. The map of this system is on page sixty-seven of this report, and an outline of the detailed specifications governing construction also accompanies the report.

Choice of a supply from Goble Creek or from the Cowlitz River will not affect the design of the distribution system, excepting that the eighteen inch (18") main on Seventh Avenue between Hemlock and Douglass Streets may be replaced by a twelve inch (12") line. The twenty four inch (24") main in the alley between Fourteenth and Fifteenth Avenues may be replaced between Hemlock and Douglass Streets by an eighteen inch (18") main, and in the event the open pressure system should be chosen for use with the Cowlitz River Supply, the remainder of the distribution system will remain as shown on the map. If for any reason the closed and direct pressure system is selected, the supply main from the Cowlitz River plant would tap the distribution system somewhere near the northeast corner, and in that event it will be necessary to revise a part of the pipe line layout on Oak Street between Commerce and Twenty-first Avenues, and in the alley between Washington Way and Cascade Way from Oak Street to Pennsylvania.

In all cases the distribution system has been so planned that extensions for townsite development west and south of Fowler Lake may be made without difficulty. The sizes of the cross town connections on Maple, Hemlock, and Delaware Streets, are sufficient to insure good pressures in the district to be developed to the west. It may become necessary, depending upon the character of the development between Fowler Lake and Mt. Solo, to later build a reservoir on Mt. Solo at the same elevation as on Cascade Hills.

The water system in that part of the townsite bounded by Oregon Way, Nineteenth Avenue, Beech Street and Missouri Boulevard had been planned prior to our reaching Longview, and was being installed while we were there. The connection between the eight inch concrete pipe line in this system and the cast iron lines above referred to should be carefully valved in order that breaks occurring in the concrete pipe may not affect the main system.

As far as possible we have conformed in the design of the distribution system to your policy of placing pipe lines in the alleys. In the warehouse district in that area bounded by Commerce Street, Seventh Avenue, Hemlock and Douglass Streets, we have used the streets because of the fact that there were railroad tracks in each alley, which render that location undesirable.

Water supply and distribution.
Explanation of tabulations:

Attached to this report as page thirty-seven to page sixty-one, inclusive, are calculations and tabulations representing the supporting data for all calculations used in the summaries on pages four, five, and six. Where the Engineering Department wishes to go back of the supporting data presented, we will be glad to supply additional information.

Your attention is particularly directed to those tabulations wherein costs of operation are considered, because in all such cases we have included interest at six per cent (6%) and a sinking fund sufficient to retire the total investment at the end of thirty years. These items have been included for the reason that if the Long-Bell Lumber Company continues to operate this utility, it will be necessary to make a charge for water service, based in part on the carrying charges. The period of thirty years is chosen for figuring sinking fund, in order to make this charge compare as nearly as possible with the cost to Longview when it becomes a municipality outside the control of the Long-Bell Lumber Company; the thirty year period approximates the period on which the City would finance.

It should be borne in mind that the figures on cost per thousand gallons of water supplied, represent costs to the L ong-Bell Lumber Company, including the item of interest and sinking fund as mentioned above, and in sale of water to the public a different rate should be used.

Longview, Washington

Sanitary sewer system.

The sanitary sewer system has been planned with the sizes and locations shown on the map on page seventy-five of this report. The basis of design of your Engineering Department was checked and accepted. In brief this provided for one hundred and thirty five gallons per capita per day over the entire residential section, allowing one hundred and fifty per cent of the above daily average for the maximum hourly rate, with an additional allowance of forty thousand gallons per acre per day for industrial development east of Commerce and south of Hudson Streets. All sewers twenty-one (21) inches and under are designed to flow one-half full at peak load, and sewers twenty-one (21) inches and over to flow two-thirds full at peak load.

The size and grade of the main outfall sewer below the intersection of Beech Street and Oregon Way, is such that territory lying above elevation six (6) and within a half mile of Fowler Lake or Oregon Way on the west, may be served by it. It will also be possible to provide sanitary drainage for the area east of Oregon Way and north of Columbia Way, and for the development south of Columbia Way, bordering on Oregon Way.

The map does not show sewers for the triangular section bounded by Oregon Way, Cascade Way and Ocean Beach Highway, because at this time the plan of connecting with sewers from West Kelso has not been developed.

It is essential that plans for the pumping station at the Columbia River be detailed just as quickly as possible so construction of a part of the pumping plant can go ahead this season. It is likely that the use, for the disposal of sewage, of low territory to the south of Beech Street, west of Oregon Way, will prove unsatisfactory this season, and it is essential that provision is made for pumping to the Columbia River before the end of next year.

Estimates of cost of the sanitary sewer system based on excavation before and after grading of streets and alleys appear on page eight, and development of unit prices on page sixty-two.

Longview, Washington

Storm water sewer systems.

In order to take care of storm water drainage from the area bounded on the south and west by Fowler Lake and on the north by Ocean Beach Highway, we have designed eight sewer districts with separate outlets. Five of these outlets go direct to the proposed drainage ditch east of and paralleling Seventh Street, and four outlets directly to Fowler Lake. The map showing the locations and sizes of these sewers appears as page seventy-seven of this report.

The design is based on a rainfall of one and one-half inches per hour with a ten minute concentration period. In our opinion this design is conservative to the extent that there will be storms at intervals which the sewers will be unable to handle. The same rainfall rate is used by the City of Portland in the design of storm sewers; but it is likely that the annual rate of rainfall, as well as its intensity will be greater at Longview than at Portland.

Estimates of cost of construction are given on page nine of the report and the details of unit costs follow as pages sixty three and four.

Longview, Washington

Cowlitz River Supply - Pumping to Cascade Hills Reservoir at Elevation 125

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population Col. 1	Total Construction cost Col. 2	Interest at 6% Col. 3	Sinking fund Col. 4	Maintenance at 3% Col. 5	Low and high service pumping Col. 6	Filter plant operation Col. 7	Total yearly operating costs Col. 8	Cost per 1,000 gallons of water supplied Col. 9
	$	$	$	$	$	$	$	$
15,000	365,850	21,950	7,690	10,980	21,870	14,560	77,050	0.094
25,000	480,430	28,830	10,100	14,420	31,930	20,360	105,640	0.077
35,000	590,980	35,460	12,420	17,730	42,400	27,430	135,440	0.070
45,000	689,410	41,360	14,490	20,680	52,270	34,950	163,750	0.066
55,000	802,940	48,180	16,880	24,090	62,670	40,570	192,390	0.064
65,000	901,540	54,100	18,950	27,050	72,600	47,370	220,070	0.062
75,000	1,000,030	60,000	21,020	30,000	82,940	53,000	246,960	0.060

Black & Veatch

Longview, Washington

Cowlitz River Supply - Pumping to Cascade Hills Reservoir at Elevation 275

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population Col. 1	Total Construction cost Col. 2	Interest at 6% Col. 3	Sinking fund Col. 4	Maintenance at 3% Col. 5	Low and high service pumping Col. 6	Filter plant operation Col. 7	Total yearly operating costs Col. 8	Cost per 1,000 gallons of water supplied Col. 9
	$	$	$	$	$	$	$	$
15,000	374,000	22,440	7,860	11,220	32,070	14,560	88,150	0.107
25,000	490,670	29,440	10,310	14,720	47,800	20,360	122,630	0.090
35,000	600,840	36,050	12,630	18,030	63,870	27,430	158,010	0.082
45,000	702,770	42,170	14,770	21,090	79,400	34,950	192,380	0.078
55,000	818,300	49,100	17,200	24,550	96,070	40,570	227,490	0.076
65,000	913,760	54,830	19,210	27,420	115,800	47,370	264,630	0.074
75,000	1,014,800	60,890	21,330	30,450	127,740	53,000	293,410	0.072

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Cowlitz River Supply - Direct Pumping - 125' Head

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population Col. 1	Total Construction cost Col. 2	Interest at 6% Col. 3	Sinking fund Col. 4	Maintenance at 3% Col. 5	Low and high service pumping Col. 6	Filter plant operation Col. 7	Total yearly operating costs Col. 8	Cost per 1,000 gallons of water supplied Col. 9
	$	$	$	$	$	$	$	$
15,000	336,950	20,220	7,080	10,110	22,330	14,560	74,300	0.090
25,000	447,830	26,870	9,410	13,430	33,130	20,360	103,200	0.075
35,000	556,480	33,390	11,700	16,690	43,740	27,430	132,950	0.069
45,000	653,210	39,190	13,730	19,600	53,470	34,950	160,940	0.065
55,000	766,440	45,990	16,110	22,990	64,140	40,570	189,800	0.063
65,000	864,740	51,880	18,180	25,940	74,400	47,370	217,770	0.061
75,000	961,930	57,720	20,220	28,860	85,000	53,000	244,800	0.060

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Cowlitz River Supply - Direct Pumping - 275' Head

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population Col. 1	Total Construction cost Col. 2	Interest at 6% Col. 3	Sinking fund Col. 4	Maintenance at 3% Col. 5	Low and high service pumping Col. 6	Filter Plant operation Col. 7	Total yearly operating costs Col. 8	Cost per 1,000 gallons of water supplied Col. 9
	$	$	$	$	$	$	$	$
15,000	345,100	20,710	7,250	10,360	33,130	14,560	86,010	0.105
25,000	458,070	27,480	9,630	13,740	50,000	20,360	121,210	0.089
35,000	566,340	33,980	11,900	16,990	66,740	27,430	157,040	0.082
45,000	666,570	39,890	14,010	19,990	82,340	34,950	191,280	0.078
55,000	781,800	46,910	16,430	23,460	99,070	40,570	226,440	0.075
65,000	876,960	52,620	18,430	26,310	115,670	47,370	260,400	0.073
75,000	976,700	58,600	20,530	29,300	127,740	53,000	289,170	0.070

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Filter Plant and Pipe Line Costs for Direct Pressure Pumping and for Pressure from Cascade Hills Reservoir at Elevations of 125 feet and 275 feet.

Population Col.1	Filter and clear well costs direct pumping Col.2	Filter clear well and reservoir costs: pumping to Cascade Hills reservoir Col. 3	Pipe Line required for direct pumping in addition to distribution system Col. 4	Pipe Line required in addition to distribution system 125' Head Col.5	Pipe Line required in addition to distribution system 275' Head Col. 6	Total cost for either 125' or 275' heads direct pumping pressure Col. 7	Total cost for either 125' or 275' heads Cascade Hills reservoir pressure Col. 8
	$	$	$	$	$	$	$
15,000	249,700	267,500	74,700	85,800	85,800	324,400	353,300
25,000	358,300	379,800	74,700	85,800	85,800	433,000	465,600
35,000	463,300	486,700	74,700	85,800	85,800	538,000	572,500
45,000	558,100	583,200	74,700	85,800	85,800	632,800	669,000
55,000	669,500	694,900	74,700	85,800	85,800	744,200	780,700
65,000	762,500	788,200	74,700	85,800	85,800	837,200	874,000
75,000	859,500	886,500	74,700	85,800	85,800	934,200	972,300

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Costs of Filter Plant - Capacities and Costs of Clear Wells and Reservoir - Required for Direct Pumping Pressure, and for Pressure from Cascade Hills Reservoir.

Population	Cost of filter	Clear well capacity - direct pumping	Clear well cost	Filter & clearwell cost plus 10% - direct pumping	Clear well capacity pumping to Cascade Hills reservoir	Clear well cost	Cost filters and clear well pumping to Cascade Hills reservoir	Cascade Hills covered reservoir (Capacity Col. (3))	Filter clearwell, and Cascade Hills reservoir cost plus 10%
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
	$		$	$		$	$	$	$
15,000	201,900	1.35	25,100	249,700	0.50	9,300	211,200	32,000	267,520
25,000	295,000	1.65	30,700	358,300	0.55	10,250	305,250	40,000	379,780
35,000	387,300	1.82	33,850	463,300	0.60	11,150	398,450	44,000	486,695
45,000	471,100	1.95	36,250	558,100	0.65	12,100	483,200	47,000	583,220
55,000	570,700	2.04	37,950	669,500	0.70	13,000	583,700	48,000	694,870
65,000	653,600	2.13	39,600	762,500	0.75	13,950	667,550	49,000	788,205
75,000	741,000	2.17	40,350	859,500	0.80	14,900	755,900	50,000	886,490

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Costs of Filter Plants for Daily Capacities of 3,380,000 to 16,880,000 gallons inclusive.

Population Col. 1	Filter capacity million gal/day Col. 2	General Construction Col. 3	Grit and Coag. basins Col. 4	Filter bldg. and filter bldg. concrete Col. 5	Miscl and extra work Col. 6	Sewers Col. 7	Pipe lines and pipe gallery Col. 8	Filter materials and equipment Col. 9	Wash water tank Col. 10	Side Tracks Col. 11	Suction line strainers and housing Col. 12	River intake Col. 13	Suction lines from intake to filters Col. 14	Total Col. 15
		$	$	$	$	$	$	$	$	$	$	$	$	$
15,000	3.38	35,500	9,000	61,100	3,500	1,300	20,900	15,500	5,500	5,000	4,600	30,000	10,000	201,900
25,000	5.63	58,500	14,800	98,000	5,800	2,100	34,400	25,500	6,300	5,000	4,600	30,000	10,000	295,000
35,000	7.88	82,500	20,900	130,000	8,200	3,000	48,600	36,000	7,100	5,000	6,000	30,000	10,000	387,300
45,000	10.13	105,400	26,800	156,000	10,500	3,800	62,100	46,000	7,900	5,000	7,600	30,000	10,000	471,000
55,000	12.38	129,500	32,900	185,000	12,900	4,700	76,300	55,400	8,700	5,000	9,300	35,000	15,000	570,700
65,000	14.63	152,400	38,700	210,000	15,200	5,600	89,800	66,400	9,500	5,000	11,000	35,000	15,000	653,600
75,000	16.88	176,400	44,800	232,000	17,600	6,400	103,900	76,900	10,300	5,000	12,700	40,000	15,000	741,000

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Goble Creek Supply - Wood and Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 125.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rates.

Population	Drainage area and pipe line right of way	Impounding reservoir	Pipe line	Cowlitz River crossing	Cascade Hills storage reservoir	Total construction	Interest at 6%	Sinking fund	Maintenance	Labor and miscl. operating costs	Total yearly operation	Cost per 1000 gal. of avg. demand
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	235,600	85,700	44,100	638,300	38,300	16,600	12,800	18,700	86,400	0.105
25,000	191,000	81,900	328,900	85,700	59,800	747,300	44,800	19,400	14,900	18,700	97,800	0.075
35,000	191,000	127,300	435,600	85,700	75,400	915,000	54,900	23,700	18,300	18,700	115,600	0.060
45,000	191,000	127,300	457,900	85,700	91,000	952,900	57,200	24,700	19,100	21,700	122,700	0.050
55,000	191,000	180,000	623,200	85,700	103,300	1,183,200	71,000	30,700	23,700	21,700	147,100	0.049
65,000	191,000	180,000	644,600	85,700	117,400	1,218,700	73,100	31,600	24,400	25,000	154,100	0.043
75,000	191,000	232,700	655,900	85,700	126,000	1,291,300	77,500	33,500	25,800	25,000	161,800	0.040

Col.3 - includes miscellaneous roads, clearing and breaker reservoirs.

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Goble Creek Supply - Wood and Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 275.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population Col. 1	Drainage area and pipe line right of way Col. 2	Impounding reservoir Col. 3	Pipe line Col. 4	Cowlitz River crossing Col. 5	Cascade Hills storage reservoir Col. 6	Total construction Col. 7	Interest at 6% Col. 8	Sinking fund Col. 9	Maintenance Col. 10	Labor and miscl. operating costs Col. 11	Total yearly operation Col. 12	Cost per 1000 gal. of avg. demand Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	319,300	85,700	44,100	722,000	43,300	18,700	14,400	18,700	95,100	0.116
25,000	191,000	81,900	406,900	85,700	59,800	825,300	49,500	21,400	16,500	18,700	106,100	0.078
35,000	191,000	127,300	597,700	85,700	75,400	1,077,100	64,600	27,900	21,500	18,700	132,700	0.069
45,000	191,000	127,300	628,800	85,700	91,000	1,123,800	67,400	29,100	32,500	21,700	140,700	0.057
55,000	191,000	180,000	662,000	85,700	103,300	1,222,000	73,300	31,700	24,400	21,700	151,100	0.050
65,000	191,000	180,000	821,700	85,700	117,400	1,395,800	83,700	36,200	27,900	25,000	172,800	0.049
75,000	191,000	232,700	857,600	85,700	126,000	1,493,000	89,600	38,700	29,900	25,000	183,200	0.045

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Goble Creek Supply - Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 125.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population	Drainage area and pipe line right of way	Impounding reservoir	Pipe line	Cowlitz River crossing	Cascade Hills storage reservoir	Total construction	Interest at 6%	Sinking fund	Maintenance	Labor and miscl. operating costs	Total yearly operation	Cost per 1000 gal. of avg. demand
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	333,900	85,700	44,100	736,600	44,200	15,500	14,700	18,700	93,100	0.113
25,000	191,000	81,900	477,700	85,700	59,800	896,100	53,800	18,800	17,900	18,700	109,200	0.080
35,000	191,000	127,300	678,200	85,700	75,400	1157,600	69,500	24,300	23,200	18,700	135,700	0.071
45,000	191,000	127,300	678,200	85,700	91,000	1173,200	70,400	24,700	23,500	21,700	140,300	0.057
55,000	191,000	180,000	953,900	85,700	103,300	1513,900	90,800	31,800	30,300	21,700	174,600	0.058
65,000	191,000	180,000	1,006,700	85,700	117,400	1580,800	94,800	33,200	31,600	25,000	184,600	0.052
75,000	191,000	232,700	1,006,700	85,700	126,000	1642,100	98,500	34,500	32,800	25,000	190,800	0.047

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Goble Creek Supply - Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 275.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate.

Population	Drainage area and pipe line right of way	Impounding reservoir	Pipe line	Cowlitz River crossing	Cascade Hills storage reservoir	Total construction	Interest at 6%	Sinking fund	Maintenance	Labor and miscl. operating costs	Total yearly operation	Cost per 1000 gal. of avg. demand
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	465,400	85,700	44,100	868,100	52,100	18,200	16,400	18,700	105,400	0.128
25,000	191,000	81,900	618,600	85,700	59,800	1,037,000	62,200	21,800	20,700	18,700	123,400	0.090
35,000	191,000	127,300	945,800	85,700	75,400	1,425,200	85,500	30,000	28,500	18,700	152,700	0.085
45,000	191,000	127,300	945,800	85,700	91,000	1,440,800	86,400	30,300	28,800	21,700	167,200	0.068
55,000	191,000	180,000	971,300	85,700	103,300	1,531,300	91,900	32,200	30,600	21,700	176,400	0.059
65,000	191,000	180,000	1,276,900	85,700	117,400	1,851,000	111,100	38,900	37,000	25,000	212,000	0.060
75,000	191,000	232,700	1,276,900	85,700	126,000	1,912,300	114,700	40,200	38,200	25,000	218,100	0.053

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Goble Creek Supply - Concrete and Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 125.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate

Population	Drainage area and pipe line right of way	Impounding reservoir	Pipe line	Cowlitz River crossing	Cascade Hills storage reservoir,	Total construction	Interest at 6%	Sinking fund	Maintenance	Labor and miscl. operating costs	Total yearly operation	Cost per 1000 gal. of avg. demand
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	373,900	85,700	44,100	776,500	46,600	16,300	15,500	18,700	97,100	0.118
25,000	191,000	81,900	497,600	85,700	59,800	916,000	55,000	19,300	18,300	18,700	111,300	0.082
35,000	191,000	127,300	676,200	85,700	75,400	1,155,600	69,300	24,300	23,100	18,700	135,400	0.071
45,000	191,000	127,300	676,200	85,700	91,000	1,171,200	70,300	24,600	23,400	21,700	140,000	0.057
55,000	191,000	180,000	685,100	85,700	103,300	1,445,100	86,700	30,400	28,900	21,700	167,700	0.056
65,000	191,000	180,000	964,500	85,700	117,400	1,538,600	92,300	32,300	30,800	25,000	180,400	0.051
75,000	191,000	232,700	964,500	85,700	126,000	1,599,900	96,000	33,600	32,000	25,000	186,600	0.045

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Goble Creek Supply - Concrete and Cast Iron Pipe Line - Cascade Hills Reservoir at Elevation 275.

Cost of project, annual operating cost, and cost per 1,000 gallons of water supplied at average demand rate

Population	Drainage area and pipe line right of way	Impounding reservoir	Pipe line	Cowlitz River crossing	Cascade Hills storage reservoir	Total construction	Interest at 6%	Sinking fund	Maintenance	Labor and miscl. operating costs	Total yearly operation	Cost per 1000 gal. of avg. demand
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13
	$	$	$	$	$	$	$	$	$	$	$	$
15,000	191,000	81,900	449,300	85,700	44,100	852,000	51,000	17,900	17,000	18,700	104,600	0.127
25,000	191,000	81,900	615,400	85,700	59,800	1,033,800	62,000	21,700	20,700	18,700	123,100	0.090
35,000	191,000	127,300	870,400	85,700	75,400	1,349,800	81,000	28,400	27,000	18,700	155,100	0.081
45,000	191,000	127,300	870,400	85,700	91,000	1,365,400	81,900	28,700	27,300	21,700	159,600	0.065
55,000	191,000	180,000	951,500	85,700	103,300	1,511,500	90,700	31,800	30,200	21,700	174,400	0.058
65,000	191,000	180,000	1,121,400	85,700	117,400	1,695,500	101,700	35,600	33,900	25,000	196,200	0.055
75,000	191,000	232,700	1,222,700	85,700	126,000	1,858,100	111,500	39,100	37,200	25,000	212,800	0.052

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Wood and Cast Iron Pipe Flow Line from Goble Creek to
Cascade Hills Reservoir at Elevation 125
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Size & Class	Unit Prices	Totals
					$	$
15,000	North Goble to Junction	2.00	10,000	12"	1.44	14,400
	South " " "	3.26	15,000	12"	1.44	21,600
	Jct. to Owl Creek R's Site	5.26	29,500	16"	1.97	58,115
	Owl Creek to 14th & Douglas	5.26	24,500	16" C	5.17	126,665
	Ocean Beach Hghy to Cascade Hills	5.26	1,500	16" C	5.17	7,755
						228,535
25,000	North Goble to Junction	3.29	10,000	14"	1.68	16,800
	South " " "	5.37	15,000	14"	1.68	25,200
	Jct. to Owl Creek R's Site	8.66	29,500	20"	2.68	79,060
	Owl Creek to 14th & Douglas	8.66	24,500	20" C	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	8.68	1,500	20" C	7.49	11,235
						315,800
35,000	North Goble to Junction	4.64	10,000	16"	1.97	19,700
	South " " "	7.58	15,000	16"	1.97	29,550
	Jct. to Owl Creek R's Site	12.22	29,500	22"	3.09	91,155
	Owl Creek to 14th & Douglas	12.22	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	12.22	1,500	24" C	9.83	14,745
						395,985
45,000	North Goble to Junction	5.93	10,000	18"	2.25	22,500
	South " " "	9.68	15,000	18"	2.25	33,750
	Jct. to Owl Creek R's Site	15.61	29,500	24"	3.54	104,430
	Owl Creek to 14th & Douglas	15.61	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	15.61	1,500	24" C	9.83	14,745
						416,260
55,000	North Goble to Junction	7.28	10,000	20"	2.68	26,800
	South " " "	11.87	15,000	20"	2.68	40,200
	Jct. to Owl Creek R's Site	19.15	29,500	26"	4.26	125,670
	Owl Creek to 14th & Douglas	19.15	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	1,500	30" C	14.38	21,570
						566,550
65,000	North Goble to Junction	8.56	10,000	20"	2.68	26,800
	South " " "	13.96	15,000	20"	2.68	40,200
	Jct. to Owl Creek R's Site	22.52	29,500	28"	4.92	145,140
	Owl Creek to 14th & Douglas	22.52	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	22.52	1,500	30" C	14.38	21,570
						586,020
75,000	North Goble to Junction	9.91	10,000	22"	3.09	30,900
	South " " "	16.18	15,000	22"	3.09	46,350
	Jct. to Owl Creek R's Site	26.09	29,500	28"	4.92	145,140
	Owl Creek to 14th & Douglas	26.09	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	26.09	1,500	30" C	14.38	21,570
						596,270

Note- All wood pipe used is for 100' head.
Total costs when transferred from this sheet are increased by 10% to cover engineering and contingencies.

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Wood and Cast Iron Pipe Flow Line from Goble Creek to
Cascade Hills Reservoir at Elevation 275
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Size & Class	Unit Prices $	Totals $
15,000	North Goble to Junction	2.00	10,000	12"	1.44	14,400
	South " " "	3.26	15,000	12"	1.44	21,600
	Jct. to Owl Creek R's Site	5.26	29,500	18"	2.25	66,375
	Owl Creek to 14th & Douglas	5.26	24,500	20" C	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	5.26	2,600	20" C	7.49	19,474
						305,354
25,000	North Goble to Junction	3,29	10,000	14"	1.68	16,800
	South " " "	5.37	15,000	14"	1.68	25,200
	Jct. to Owl Creek R's Site	8.66	29,500	20"	2.68	79,060
	Owl Creek to 14th & Douglas	8.66	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	8.66	2,600	24" C	9.83	25,558
						387,453
35,000	North Goble to Junction	4.64	10,000	16"	1.97	19,700
	South " " "	7.58	15,000	16"	1.97	29,550
	Jct. to Owl Creek R's Site	12.22	29,500	24"	3.54	104,430
	Owl Creek to 14th & Douglas	12.22	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	12.22	2,600	30" C	14.38	37,388
						543,378
45,000	North Goble to Junction	5.93	10,000	18"	2.25	22,500
	South " " "	9.68	15,000	18"	2.25	33,750
	Jct. to Owl Creek R's Site	15.61	29,500	26"	4.26	125,670
	Owl Creek to 14th & Douglas	15.61	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	15.61	2,600	30" C	14.38	37,388
						571,618
55,000	North Goble to Junction	7.28	10,000	20"	2.68	26,800
	South " " "	11.87	15,000	20"	2.68	40,200
	Jct. to Owl Creek R's Site	19.15	29,500	28"	4.92	145,140
	Owl Creek to 14th & Douglas	19.15	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	2,600	30" C	14.38	37,388
						601,838
65,000	North Goble to Junction	8.56	10,000	20"	2.68	26,800
	South " " "	13.96	15,000	20"	2.68	40,200
	Jct. to Owl Creek to R's Site	22.52	29,500	30"	5.54	163,430
	Owl Creek to 14th & Douglas	22.52	24,500	36" C	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	22.52	2,600	36" C	19.06	49,556
						746,956
75,000	North Goble to Junction	9.91	10,000	22"	3.09	30,900
	South " " "	16.18	15,000	22"	3.09	46,350
	Jct. to Owl Creek R's Site	26.09	29,500	32"	6.30	185,850
	Owl Creek to 14th & Douglas	26.09	24,500	36" C	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	26.09	2,600	36" C	19.06	49,556
						779,626

Note- All wood pipe used is for 100' head.
Total costs when transferred from this sheet are incrdased by 10% to cover engineering and contingencies.

Black & Veatch

Longview, Washington

Cast Iron Pipe Flow Line from Goble Creek to
Cascade Hills Reservoir at Elevation 125
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Size & Class	Unit Prices $	Totals $
15,000	North Goble to Junction	2.00	10,000	12" A	2.94	29,400
	South " " "	3.26	15,000	12" A	2.94	44,100
	Jct. to Owl Creek R's Site	5.26	29,500	16" A	4.28	126,260
	Owl Creek to 14th & Douglas	5.26	24,500	16" C	5.17	126,665
	Ocean Beach Hghy to Cascade Hills	5.26	1,500	16" C	5.17	7,755
						334,180
25,000	North Goble to Junction	3.29	10,000	16" A	4.28	42,800
	South " " "	5.37	15,000	16" A	4.28	64,200
	Jct. to Owl Creek R's Site	8.66	29,500	20" A	6.01	177,295
	Owl Creek to 14th & Douglas	8.66	24,500	20" C	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	8.66	1,500	20" C	7.49	11,235
						479,035
35,000	North Goble to Junction	4.64	10,000	18" A	5.08	50,800
	South " " "	7.58	15,000	18" A	5.08	76,200
	Jct. to Owl Creek R's Site	12.22	29,500	24" A	7.93	233,935
	Owl Creek to 14th & Douglas	12.22	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	12.22	1,500	24" C	9.83	14,745
						616,515
45,000	North Goble to Junction	5.93	10,000	18" A	5.08	50,800
	South " " "	9.68	15,000	18" A	5.08	76,200
	Jct. to Owl Creek to R's Site	15.61	29,500	24" A	7.93	233,935
	Owl Creek to 14th & Douglas	15.61	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	15.61	1,500	24" C	9.83	14,745
						616,515
55,000	North Goble to Junction	7.28	10,000	20" A	6.01	60,100
	South " " "	11.87	15,000	20" A	6.01	90,150
	Jct. to Owl Creek to R's Site	19.15	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	19.15	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	1,500	30" C	14.38	21,570
						867,215
65,000	North Goble to Junction	8.56	10,000	24" A	7.93	79,300
	South " " "	13.96	15,000	24" A	7.93	118,950
	Jct. to Owl Creek R's Site	22.52	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	22.52	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	22.52	1,500	30" C	14.38	21,570
						915,215
75,000	North Goble to Junction	9.91	10,000	24" A	7.93	79,300
	South " " "	16.18	15,000	24" A	7.93	118,950
	Jct. to Owl Creek R's Site	26.09	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	26.09	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	26.09	1,500	30" C	14.38	21,570
						915,215

Note- Total costs when transferred from this sheet are increased by 10% to cover engineering and contingencies.

Black & Veatch

Longview, Washington

Cast Iron Pipe Flow Line from Goble Creek to
Cascade Hills Reservoir at Elevation 275
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Sizes & Class	Unit Prices $	Totals $
15,000	North Goble to Junction	2.00	10,000	12" A	2.94	29,400
	South " " "	3.26	15,000	12" A	2.94	44,100
	Jct. to Owl Creek R's Site	5.26	29,500	20" A	6.01	177,295
	Owl Creek to 14th & Douglas	5.26	24,500	20" C	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	5.26	2,600	20" C	7.49	19,474
						453,774
25,000	North Goble to Junction	3.29	10,000	16" A	4.28	42,800
	South " " "	5.37	15,000	16" A	4.28	64,200
	Jct. to Owl Creek R's Site	8.66	29,500	24" A	7.93	233,935
	Owl Creek to 14th & Douglas	8.66	24,500	24" C	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	8.66	2,600	24" C	9.83	25,558
						607,328
35,000	North Goble to Junction	4.64	10,000	18" A	5.08	50,800
	South " " "	7.58	15,000	18" A	5.08	76,200
	Jct. to Owl Creek R's Site	12.22	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	12.22	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	12.22	2,600	30" C	14.38	37,388
						859,783
45,000	North Goble to Junction	5.93	10,000	18" A	5.08	50,800
	South " " "	9.68	15,000	18" A	5.08	76,200
	Jct. to Owl Creek R's Site	15.61	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	15.61	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	15.61	2,600	30" C	14.38	37,388
						859,783
55,000	North Goble to Junction	7.28	10,000	20" A	6.01	60,100
	South " " "	11.87	15,000	20" A	6.01	90,150
	Jct. to Owl Creek R's Site	19.15	29,500	30" A	11.63	343,085
	Owl Creek to 14th & Douglas	19.15	24,500	30" C	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	2,600	30" C	14.38	37,388
						883,033
65,000	North Goble to Junction	8.56	10,000	24" A	7.93	79,300
	South " " "	13.96	15,000	24" A	7.93	118,950
	Jct. to Owl Cfeek R's Site	22.52	29,500	36" A	15.12	446,040
	Owl Creek to 14th & Douglas	22.52	24,500	36" C	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	22.52	2,600	36" C	19.06	49,556
						1,160,816
75,000	North Goble to Junction	9.91	10,000	24" A	7.93	79,300
	South " " "	16.18	15,000	24" A	7.93	118,950
	Jct. to Owl Creek R's Site	26.09	29,500	36" A	15.12	446,040
	Owl Creek to 14th & Douglas	26.09	24,500	36" C	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	26.09	2,600	36" C	19.06	49.556
						1,160,816

Note- Total costs when transferred from this sheet are increased by 10% to cover engineering and contingencies.

Black & Veatch

Concrete and Cast Iron Pipe Flow Line from Goble Creek to Cascade Hills Reservoir at Elevation 125
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Size & Class	Unit Prices $	Totals $
15,000	North Goble to Junction	2.00	10,000	12" B	2.79	27,900
	South " " "	3.26	15,000	12" C	3.20	48,000
	Jct. to Owl Creek R's Site	5.26	29,500	18" C	5.35	157,825
	Owl Creek to 14th & Douglas	5.26	24,500	16" *	5.17	126,665
	Ocean Beach Hghy to Cascade Hills	5.26	1,500	16" *	5.17	7,755
						368,145
25,000	North Goble to Junction	3.29	10,000	15" B	3.69	36,900
	South " " "	5.37	15,000	15" C	4.23	63,450
	Jct. to Owl Creek R's Site	8.66	29,500	21" C	6.64	195,880
	Owl Creek to 14th & Douglas	8.66	24,500	20" *	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	8.66	1,500	20" *	7.49	11,235
						490,970
35,000	North Goble to Junction	4.64	10,000	18" B	4.67	46,700
	South " " "	7.58	15,000	18" C	5.35	80,250
	Jct. to Owl Creek R's Site	12.22	29,500	24" C	7.87	232,165
	Owl Creek to 14th & Douglas	12.22	24,500	24" *	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	12.22	1,500	24" *	9.83	14,745
						614,695
45,000	North Goble to Junction	5.93	10,000	18" B	4.67	46,700
	South " " "	9.68	15,000	18" C	5.35	80,250
	Jct. to Owl Creek R's Site	15.61	29,500	24" C	7.87	232,165
	Owl Creek to 14th & Douglas	15.61	24,500	24" *	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	15.61	1,500	24" *	9.83	14,745
						614,695
55,000	North Goble to Junction	7.28	10,000	21" B	5.65	56,500
	South " " "	11.87	15,000	21" C	6.64	99,600
	Jct. to Owl Creek R's Site	19.15	29,500	27" C	9.31	274,645
	Owl Creek to 14th & Douglas	19.15	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	1,500	30" *	14.38	21,570
						804,625
65,000	North Goble to Junction	8.56	10,000	24" B	6.57	65,700
	South " " "	13.96	15,000	24" C	7.87	118,050
	Jct. to Owl Creek R's Site	22.52	29,500	30" C	10.82	319,190
	Owl Creek to 14th & Douglas	22.52	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	22.52	1,500	30" *	14.38	21,570
						876,820
75,000	North Goble to Junction	9.91	10,000	24" B	6.57	65,700
	South " " "	16.18	15,000	24" C	7.87	118,050
	Jct. to Owl Creek R's Site	26.09	29,500	30" C	10.82	319,190
	Owl Creek to 14th & Douglas	26.09	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	26.09	1,500	30" *	14.38	21,570
						876,820

Note- * Class "C" Cast Iron Pipe
Class "B" Concrete pipe represents 25' to 80' head
Class "C" Concrete pipe represents 80' to 140' head.
Total costs when transferred from this sheet are increased by 10% to cover engineering and contingencies.

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Longview, Washington

Concrete and Cast Iron Pipe Flow Line from Goble Creek to Cascade Hills Reservoir at Elevation 275
Tabulation of sizes, capacities, quantity and estimated cost

Population	Location	Cu.Ft. Sec.	Lin. Ft.	Size & Class	Unit Prices	Totals
					$	$
15,000	North Goble to Junction	3.00	10,000	12" B	2.79	27,900
	South " " "	3.26	15,000	12" C	3.20	48,000
	Jct. to Owl Creek R's Site	5.26	29,500	18" C	5.35	157,825
	Owl Creek to 14th & Douglas	5.26	24,500	20" *	7.49	183,505
	Ocean Beach Hghy to Cascade Hills	5.26	2,600	20" *	7.49	19,474
						436,704
25,000	North Goble to Junction	3,29	10,000	15" B	3.69	36,900
	South " " "	5.37	15,000	15" C	4.23	63,450
	Jct. to Owl Creek R's Site	8.66	29,500	24" C	7.87	232,165
	Owl Creek to 14th & Douglas	8.66	24,500	24" *	9.83	240,835
	Ocean Beach Hghy to Cascade Hills	8.66	2,600	24" *	9.83	25,558
						598,908
35,000	North Goble to Junction	4.64	10,000	18" B	4.67	46.700
	South " " "	7.58	15,000	18" C	5.35	80,250
	Jct. to Owl Creek R's Site	12.22	29,500	27" C	9.31	274,645
	Owl Creek to 14th & Douglas	12.22	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	12.22	2,600	30" *	14.38	37,388
						791,293
45,000	North Goble to Junction	5.93	10,000	18" B	4.67	46,700
	South " " "	9.68	15,000	18" C	5.35	60,250
	Jct. to Owl Creek R's Site	15.61	29,500	27" C	9.31	274,645
	Owl Creek to 14th & Douglas	15.61	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	15.61	2,600	30" *	14.38	27,388
						791,293
55,000	North Goble to Junction	7.28	10,000	21" B	5.65	56,500
	South " " "	11.87	15,000	21" C	6.64	99,600
	Jct. to Owl Creek R's Site	19.15	29,500	30" C	10.82	319,190
	Owl Creek to 14th & Douglas	19.15	24,500	30" *	14.38	352,310
	Ocean Beach Hghy to Cascade Hills	19.15	2,600	30" *	14.38	37,388
						864,988
65,000	North Goble to Junction	8.65	10,000	24" B	6.57	65,700
	South " " "	13.96	15,000	24" C	7.87	118,050
	Jct. to Owl Creek R's Site	22.52	29,500	30" C	10.82	319,190
	Owl Creek to 14th & Douglas	22.52	24,500	36" *	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	22.52	2,600	36" *	19.06	49,556
						1,019,466
75,000	North Goble to Junction	9.91	10,000	24" B	6.57	65,700
	South " " "	16.18	15,000	24" C	7.87	118,050
	Jct. to Owl Creek R's Site	26.09	29,500	36" C	13.94	411,230
	Owl Creek to 14th & Douglas	26.09	24,500	36" *	19.06	466,970
	Ocean Beach Hghy to Cascade Hills	26.09	2,600	36" *	19.06	49.556
						1,111,506

Note- * Class "C" Cast Iron Pipe
Class "B" concrete pipe represents 25' to 80' head
Class "C" concrete pipe represents 80' to 140' head
Total costs when transferred from this sheet are increased by 10% to cover engineering and contingencies.

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Development of Unit Prices for 100 foot head Wood Pipe, sizes 12" to 30" inclusive.

Size of pipe; internal diameter in inches	(1)	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"
Average cover over pipe; feet	(2)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average depth of trench; (2) plus O.D. of pipe	(3)	2.3	2.4	2.6	2.8	2.8	3.0	3.3	3.5	3.7	3.8
*Average width of trench; O.D. of pipe plus 1 foot	(4)	2.3	2.4	2.6	2.8	2.8	3.0	3.3	4.5	4.7	4.8
Cu.Yds. earth excavation; 60% of (3) x (4) / 27	(5)	0.12	0.13	0.15	0.17	0.17	0.20	0.24	0.35	0.39	0.41
Cu.Yds. rock excavation; 40$ of (3) x (4) / 27	(6)	0.08	0.09	0.10	0.12	0.12	0.13	0.16	0.23	0.26	0.27
Cost of pipe per lin. ft.; f.o.b. Kelso; dollars	(7)	1.00	1.19	1.38	1.55	1.90	2.17	2.39	2.75	3.15	3.65
Unloading, hauling, distributing pipe per ft.; dollars	(8)	0.08	0.09	0.11	0.13	0.16	0.19	0.25	0.27	0.38	0.41
Earth excavation, per ft.; (5) x.60; dollars	(9)	0.07	0.08	0.09	0.10	0.10	0.12	0.14	0.21	0.23	0.24
Rock excavation, per ft.; (6) x 2.00; "	(10)	0.16	0.18	0.20	0.24	0.24	0.26	0.32	0.46	0.52	0.54
Laying, Lining and jointing, per foot; "	(11)	0.03	0.04	0.06	0.08	0.12	0.16	0.20	0.25	0.27	0.30
Backfilling per foot; (5) plus (6) x .10; dollars	(12)	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.06	0.07	0.07
Total labor per foot, (8) to (12) inclusive; dollars	(13)	0.36	0.41	0.49	0.58	0.65	0.76	0.95	1.25	1.47	1.56
Liability insurance and public liability per foot; at 5% on labor; 5% of (13); dollars	(14)	0.02	0.02	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08
Contractors overhead and profit, per foot; 15% of (13) plus (14)	(15)	0.06	0.06	0.08	0.09	0.10	0.12	0.15	0.20	0.23	0.25
Total cost per foot of pipe line; (7) plus((13) to (15) inclusive); dollars	(16)	1.44	1.68	1.97	2.25	2.68	3.09	3.54	4.26	4.92	5.54

Note - Sizes 26" and larger are continuous stave pipe.

* For continuous stave pipe, average width is taken at O.D. of pipe plus 2 feet.

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Longview, Washington

Costs of Class "A" Cast Iron Pipe Line

Size of pipe		12"	14"	16"	18"	20"	24"	30"	36"
Average cover over pipe; feet	(1)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average depth of trench; (1) + O.D. of pipe	(2)	2.1	2.3	2.5	2.6	2.8	3.2	3.6	4.2
Average width of trench	(3)	2.3	2.3	2.3	2.7	2.8	3.2	3.7	4.2
Outside diameter of pipe bells; feet	(4)	1.4	1.6	1.8	2.0	2.2	2.6	3.1	3.7
Average cu. yds. excavation; per ft. of trench, (2)x(3)/27	(5)	0.18	0.20	0.21	0.26	0.29	0.38	0.49	0.65
Bell hole excavation 3.5' long, .75' wide; (2)x3.5x ((5)+1-(3)) / 12/ 27	(6)	0.014	0.021	0.028	0.021	0.028	0.032	0.035	0.046
3.5 x (.75+((5)-O.D. of pipe) / 2)((5)+1) / 12 / 27	(7)	0.028	0.030	0.032	0.036	0.038	0.042	0.050	0.056
Total excavation per foot of pipe; (4)+(8)	(8)	0.22	0.25	0.27	0.32	0.36	0.45	0.58	0.75
Cement required per joint; cu. ft.	(9)	0.054	0.062	0.084	0.096	0.104	0.124	0.152	0.182
Jute required per joint: pounds	(10)	0.67	0.89	1.03	1.10	1.38	1.65	2.27	3.30
Average weight of pipe; per foot: allowing 3% excess weight; pounds	(11)	75.0	92.4	111.6	133.0	154.6	210.2	300.5	403.5
Earth excavation, per fot.; 60% of (8) x $0.60; dollars	(12)	0.08	0.09	0.10	0.12	0.13	0.16	0.21	0.27
Rock excavation, per ft.; 40% of (8) x $2.00; "	(13)	0.18	0.20	0.22	0.27	0.29	0.36	0.46	0.60
Unloading, hauling, and distributing pipe; per foot; dollars	(14)	0.16	0.18	0.23	0.27	0.40	0.47	0.95	0.95
Laying, yarning and jointing pipe; per foot; dollars	(15)	0.09	0.10	0.14	0.15	0.22	0.25	0.37	0.45
Backfilling per foot; (8) x $0.10; dollars	(16)	0.02	0.03	0.03	0.03	0.04	0.05	0.06	0.08
Total labor per foot; (12) to (16) inclusive; dollars	(17)	0.53	0.60	0.72	0.84	1.08	1.29	2.05	2.35
Liability insurance and public liability per foot; 5% of (17) dollars	(18)	0.03	0.03	0.04	0.04	0.05	0.07	0.10	0.12
Cement joints, per foot; (9) x $0.70 / 12; dollars	(19)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Jute joints, per foot; (10) x $0.12 / 12; "	(20)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03
Sub total; labor per foot; (17) to (20) inclusive; dollars	(21)	0.58	0.65	0.78	0.90	1.15	1.35	2.18	2.51
Contractors overhead and profit; 15% of (21); "	(22)	0.09	0.10	0.12	0.14	0.17	0.20	0.33	0.38
Pipe per foot; dollars	(23)	2.27	2.80	3.38	4.04	4.69	6.38	9.12	12.23
Total cost of pipe line per foot; (21) to (23) inclusive	(24)	2.94	3.55	4.28	5.08	6.01	7.93	11.63	15.12

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Longview, Washington

Costs of Class "C" Cast Iron Pipe Line

Size of pipe		12"	14"	16"	18"	20"	24"	30"	36"
Average cover over pipe; feet	(1)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average depth of trench; (1) + O.D. of pipe	(2)	2.1	2.3	2.5	2.6	2.8	3.2	3.6	4.2
Average width of trench	(3)	2.3	2.3	2.3	2.7	2.8	3.2	3.7	4.2
Outside diameter of pipe bells; feet	(4)	1.4	1.6	1.8	2.0	2.2	2.6	3.1	3.7
Average cu.yds. excavation; per.ft.of trench,(2)x(3) / 27	(5)	0.18	0.20	0.21	0.26	0.29	0.38	0.49	0.65
Bell hole excavation 3.5' long,.75' wide;(2)x3.5x ((5)+1-(3)) / 12 / 27	(6)	0.014	0.021	0.028	0.021	0.028	0.032	0.035	0.046
3.5 x (.75+((5)-O.D. of pipe) / 2) (5)+1) / 12 / 27	(7)	0.028	0.030	0.032	0.036	0.038	0.042	0.050	0.056
Total excavation per foot of pipe; (4)+(8)	(8)	0.22	0.25	0.27	0.32	0.36	0.45	0.58	0.75
Cement required per joint; cu.ft.	(9)	0.054	0.062	0.084	0.096	0.104	0.124	0.152	0.182
Jute required per joint; pounds	(10)	0.67	0.89	1.03	1.10	1.38	1.65	2.27	3.30
Average weight of pipe;per foot:allowing 3% excess weight; pounds	(11)	94.6	120.3	148.3	180.5	214.5	287.7	412.4	562.0
Earth excavation,per ft.;60% of (8) x $0.60;dollars	(12)	0.08	0.09	0.10	0.12	0.13	0.16	0.21	0.27
Rock excavation, per ft.; 40% of (8) x $2.00 "	(13)	0.18	0.20	0.22	0.27	0.29	0.36	0.46	0.60
Unloading,hauling,and distributing pipe;per foot:dollars	(14)	0.16	0.18	0.23	0.27	0.40	0.47	0.95	0.95
Laying,yarning and jointing pipe;per foot: dollars	(15)	0.09	0.10	0.14	0.15	0.22	0.25	0.37	0.45
Backfilling per foot: (8) x $0.10: dollars	(16)	0.02	0.03	0.03	0.03	0.04	0.05	0.06	0.08
Total labor per foot; (12) to (16) inclusive; dollars	(17)	0.53	0.60	0.72	0.84	1.08	1.29	2.05	2.35
Liability insurance and public liability per foot;5% of (17) dollars	(18)	0.03	0.03	0.04	0.04	0.05	0.07	0.10	0.12
Cement joints, per foot; (9) x $0.70 / 12; dollars	(19)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Jute Joints, per foot; (10) x $0.12 / 12; "	(20)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03
Sub total; labor per foot; (17) to (20) inclusive:dollars	(21)	0.58	0.65	0.78	0.90	1.15	1.35	2.18	2.51
Contractors overhead and profit;15% of (21); "	(22)	0.09	0.10	0.12	0.14	0.17	0.20	0.33	0.38
Pipe per foot: dollars	(23)	2.72	3.46	4.27	5.19	6.17	8.28	11.87	16.17
Total cost of pipe line per foot; (21) to (23) inclusive	(24)	3.39	4.21	5.17	6.23	7.49	9.83	14.38	19.06

Black & Veatch

Longview, Washington

Cost Per Foot of Class "C" Cast Iron Pipe in Distribution System.

Size of Pipe		6"	8"	10"	12"	14"	16"	18"	24"
Lead required, pounds per joint	(1)	10.25	13.25	16.00	19.00	22.0	30.0	33.8	44.0
Lead required, pounds per foot of pipe (1) + 10% Waste / 12	(2)	0.94	1.22	1.45	1.74	2.02	2.75	3.10	4.03
Jute required, per joint, pounds	(3)	0.31	0.44	0.53	0.61	0.81	0.94	1.00	1.50
Jute required, per foot of pipe, (3) + 10% Waste / 12; pounds	(4)	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.14
Avg. weight of pipe per foot; pounds	(5)	35.8	52. 1	70.8	91.7	116.7	143.8	175.0	279.2
Excavation per foot of trench, cu. yds.	(6)	0.28	0.35	0.38	0.42	0.47	0.51	0.54	0.71
Unloading, hauling, distributing per foot; dollars	(7)	0.040	0.056	0.083	0.111	0.111	0.167	0.167	0.333
Cost Excavation, per foot of tr. (6) x $0.60; "	(8)	0.168	0.204	0.240	0.306	0.282	0.306	0.324	0.426
Laying, Calking, etc., per foot; dollars	(9)	0.065	0.088	0.100	0.122	0.138	0.180	0.203	0.322
Backfilling, per foot; dollars	(10)	0.03	0.03	0.03	0.05	0.05	0.05	0.05	0.05
Total labor, (7) to (10) inclusive	(11)	0.303	0.378	0.453	0.589	0.581	0.703	0.744	1.131
Liability insurance and public liability; 5% of (11)	(12)	0.015	0.019	0.023	0.029	0.029	0.036	0.037	0.057
Lead, per foot of pipe (2) x $0.12; dollars	(13)	0.113	0.146	0.174	0.209	0.242	0.330	0.372	0.484
Jute, per foot of pipe (4) x $0.12; "	(14)	0.004	0.005	0.006	0.007	0.008	0.010	0.011	0.017
Total pipe laying (11) to (14), inclusive; dollars	(15)	0.435	0.548	0.656	0.834	0.860	1.078	1.164	1.689
Contractors overhead and profit, 15% of (15) "	(16)	0.065	0.082	0.098	0.125	0.129	0.162	0.175	0.253
Total pipe laying (15) + (16); dollars	(17)	0.500	0.630	0.754	0.959	0.989	1.240	1.339	1.942
Cost of pipe, per foot, f.o.b. Longview; dollars	(18)	1.03	1.50	2.04	2.64	3.36	4.14	5.03	8.04
Cost of pipe laid, per foot, (17) + (18); "	(19)	1.53	2.13	2.79	3.60	4.35	5.38	6.37	9.98

Note:- Excavation in line (6) is figured from original ground profils.

Black & Veatch

<u>Longview, Washington</u>

Costs of concrete pipe line for 25 to 80 foot heads

		12"	15"	18"	21"	24"	27"	30"	36"
Internal diameter of pipe in inches		12"	15"	18"	21"	24"	27"	30"	36"
Average cover over pipe; feet	(1)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Outside diameter of pipe; feet	(2)	1.3	1.6	1.9	2.2	2.5	2.8	3.0	3.5
Average depth of trench; (1) plus (2); feet	(3)	2.3	2.6	2.9	3.2	3.5	3.8	4.0	4.5
Average width of trench; (2) plus 1.5; feet	(4)	2.8	3.1	3.4	3.7	4.0	4.3	4.5	5.0
Excavation per ft. of trench; (3) x (4) / 27; cu. yds.	(5)	0.24	0.30	0.37	0.44	0.52	0.61	0.67	0.83
Pipe per foot f.o.b. Longview; dollars	(6)	1.25	1.75	2.25	2.75	3.25	*3.80	4.60	6.00
Unloading, hauling and distributing pipe per ft.; dollars	(7)	0.26	0.33	0.43	0.50	0.64	0.78	0.95	1.17
Earth excavation, per ft.; 60% of (5) x $0.60; dollars	(8)	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.30
Rock excavation, " "; 40% of (5) x $2.00; "	(9)	0.19	0.24	0.30	0.35	0.42	0.49	0.54	0.66
Laying and jointing, per foot; dollars	(10)	0.72	0.90	1.10	1.25	1.45	*1.65	1.80	2.15
Backfilling per foot; (5) x $0.10; dollars	(11)	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08
Total labor per foot, (7) to (11) inclusive; dollars	(12)	1.28	1.61	2.00	2.40	2.75	3.20	3.60	4.36
Liability insurance and public liability per foot; 5% of (12); dollars	(13)	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.22
Contractors overhead and profit, per foot; 15% of (12) and (13); dollars	(14)	0.20	0.25	0.32	0.38	0.43	0.50	0.57	0.69
Total pipe line cost per foot; (6),(12),(13) and (14);dollars	(15)	2.79	3.69	4.67	5.65	6.57	7.66	8.95	11.27

* Estimated.
Lines (6) and (10) from data furnished by Longview Concrete Pipe Company.

Black & Veatch

Longview, Washington

Costs of concrete pipe line for 80 to 100 foot heads

Internal diameter of pipe in inches.		12"	15"	18"	21"	24"	27"	30"	36"
Average cover over pipe; feet	(1)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Outside diameter of pipe; feet	(2)	1.3	1.6	1.9	2.2	2.5	2.8	3.0	3.5
Average depth of trench; (1) plus (2); feet	(3)	2.3	2.6	2.9	3.2	3.5	3.8	4.0	4.5
Average width of trench; (2) plus 1.5; feet	(4)	2.8	3.1	3.4	3.7	4.0	4.3	4.5	5.0
Excavation per ft of trench; (3) x (4) / 27; cu. yds.	(5)	0.24	0.30	0.37	0.44	0.52	0.61	0.67	0.83
Pipe per foot f.o.b. Longview; dollars	(6)	1.50	2.10	2.75	3.50	4.25	*5.15	6.10	8.25
Unloading, hauling and distributing pipe per ft; dollars	(7)	0.26	0.33	0.43	0.60	0.64	0.78	0.95	1.17
Earth excavation, per ft.; 60% of (5) x $0.60; dollars	(8)	0.09	0.11	0.13	0.16	0.19	0.22	0.24	0.30
Rock excavation, " " ; 40% of (5) x $2.00; "	(9)	0.19	0.24	0.30	0.35	0.42	0.49	0.54	0.66
Laying and jointing, per foot; dollars	(10)	0.85	1.05	1.25	1.45	1.70	*1.90	2.10	2.50
Backfilling per foot; (5) x $0.10; dollars	(11)	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08
Total labor per foot, (7) to (11) inclusive; dollars	(12)	1.41	1.76	2.15	2.60	3.00	3.45	3.90	4.71
Liability insurance and public liability per foot; 5% of (12); dollars	(13)	0.07	0.09	0.11	0.13	0.15	0.17	0.20	0.24
Contractors overhead and profit, per foot; 15% of (12) and (13); dollars	(14)	0.22	0.28	0.34	0.41	0.47	0.54	0.62	0.74
Total pipe line cost per foot; (6),(12),(13) and (14); dollars	(15)	3.20	4.23	5.35	6.64	7.87	9.31	10.82	13.94

* Estimated.
Lines (6) and (10) from data furnished by Longview Concrete Pipe Company

Black & Veatch

Longview, Washington

Development of Prices Per Foot of Concrete Pipe for Sanitary Sewers Sizes 8" to 36" inclusive.

		8"	10"	12"	15"	18"	21"	24"	27"	30"	36"
Pipe; feet	(1)	18,900	68,928	17,925	5,035	2,475	3,700	4,156	1,320	3,670	6,500
Excavation - sewer to subgrade; cu. yds.	(2)	10,487	49,499	17,512	3,294	2,783	5,704	7,302	2,262	7,392	13,736
Excavation - sewer to profile; cu. yds.	(3)	12,240	45,936	15,380	5,768	3,566	7,665	7,748	2,256	7,577	13,736
Avg. excavation (after grading) per ft. of pipe; cu. yds.	(4)	0.555	0.718	0.977	0.655	1.125	1.542	1.757	1.715	2.013	2.113
Pipe per foot f.o.b. Longview	(5)	0.32	0.45	0.85	1.20	1.50	1.75	2.00	2.50	2.85	3.50
Hauling and distributing	(6)	0.07	0.08	0.08	0.12	0.15	0.18	0.33	0.44	0.44	0.83
Backfilling	(7)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.10	0.10	0.10
Laying Pipe	(8)	0.05	0.06	0.07	0.08	0.11	0.15	0.18	0.24	0.34	0.42
Excavation, (4) x 0.60 - 8" to 24" incl. (4) x 1.60 -27" to 36" "	(9)	0.333	0.431	0.586	0.393	0.675	0.925	1.054	2.744	3.221	3.38
Total labor; (6) to (9) inclusive	(10)	0.483	0.601	0.766	0.623	0.965	1.285	1.594	3.524	4.101	4.73
Liability insurance and public liability; 6% of (10)	(11)	0.029	0.036	0.046	0.037	0.058	0.077	0.096	0.211	0.246	0.28
Total pipe laying; (10) and (11)	(12)	0.512	0.637	0.812	0.660	1.023	1.362	1.690	3.735	4.347	5.01
Contractors overhead and profit; 15% of (12)	(13)	0.077	0.096	0.122	0.099	0.153	0.204	0.254	0.560	0.652	0.75
Total cost laying pipe; (12) + (13)	(14)	0.589	0.733	0.934	0.759	1.176	1.566	1.944	4.295	4.999	5.76
Total cost pipe laid after grading; (14)+(5)	(14A)	0.91	1.18	1.78	1.96	2.68	3.32	3.94	6.80	7.85	9.26
Avg. excavation (before grading) per ft. of pipe; cu. yds.	(15)	0.648	0.667	0.858	1.146	1.440	2.071	1.865	1.708	2.062	2.113
Excavation cost; (15) x 0.60 - 8" to 24" incl. (15) x 1.60 -27" to 36" "	(16)	0.389	0.406	0.515	0.688	0.864	1.243	1.119	2.733	3.299	3.38
Total labor; (5),(7),(8),(16)	(17)	0.539	0.576	0.695	0.918	1.154	1.603	1.659	3.513	4.179	4.73
Liability insurance and public liability: 6% of (17)	(18)	0.032	0.035	0.042	0.055	0.069	0.096	0.100	0.211	0.251	0.28
Total pipe laying; (17) and (18)	(19)	0.571	0.611	0.737	0.973	1.223	1.699	1.759	3.724	4.430	5.01
Contractors profit and overhead; 15% of (19)	(20)	0.086	0.092	0.111	0.146	0.183	0.255	0.264	0.559	0.665	0.75
Total cost laying pipe; (19) + (20)	(21)	0.657	0.703	0.848	1.119	1.406	1.954	2.023	4.283	5.095	5.76
Total cost pipe laid before grading; (20)+(5)	(21A)	0.98	1.15	1.70	2.32	2.91	3.70	4.02	6.78	7.95	9.26

Black & Veatch

Longview, Washington

Development of Prices Per foot of Concrete Pipe for Storm Sewers Sizes 12" to 54" inclusive

		12"	15"	18"	21"	24"	27"	30"	36"	42"	48"	54"	12"Inle Lines
Avg. excavation (before grading streets) per ft. of pipe; cu. yds.	(1)	.571	.509	.635	.712	1.212	1.496	1.282	2.035	1.305	2.344	2.625	2.59
Pipe Cost (Conc.) Per Ft. f.o.b. Longview	(2)	.85	1.20	1.50	1.75	2.00	2.50	2.85	3.50	4.40	5.50	6.10	.85
Hauling and distributing	(3)	.08	.12	.15	.18	.33	.44	.44	.83	.83	2.50	2.50	.08
Excavation, (1) x 0.60 - 12" to 24" incl. (1) x 1.60 - 27" to 54" "	(4)	.34	.31	.38	.43	.73	2.39	2.05	3.26	2.09	3.75	4.20	.16
Backfilling	(5)	.03	.03	.03	.03	.03	.10	.10	.10	.10	.10	.10	.03
Pipe Laying	(6)	.07	.08	.11	.15	.18	.24	.34	.43	.57	.70	.96	.07
Total Labor; (3) to (6) inclusive	(7)	.52	.54	.67	.79	1.27	3.17	2.93	4.62	3.59	7.05	7.76	.34
Liability insurance and public liability; 6% of (7)	(8)	.03	.03	.04	.05	.08	.19	.18	.28	.21	.42	.46	.02
Total pipe laying; (7) and (8)	(9)	.55	.57	.71	.84	1.35	3.36	3.11	4.90	3.80	7.47	8.22	.36
Contractors profit and overhead; 15% of (9)	(10)	.08	.09	.11	.13	.20	.50	.47	.73	.57	1.12	1.23	.05
Total Pipe Laying (9) + (10)	(11)	.63	.66	.82	.97	1.55	3.86	3.58	5.63	4.37	8.59	9.45	.41
Total cost of pipe laid (2) + (11); dollars	(12)	1.48	1.86	2.32	2.72	3.55	6.36	6.43	9.13	8.77	14.09	15.55	1.26

Black & Veatch

Longview, Washington

Development of Prices Per Foot of Concrete Pipe for Storm Sewers Sizes 12" to 54", inclusive.

		12"	15"	18"	21"	24"	27"	30"	36"	42"	48"	54"	12" Inlet Lines
Avg. excavation (after grading streets) per ft. of pipe; cu. yds.	(1)	.378	.397	.575	.512	.875	1.174	1.162	1.738	1.298	2.167	2.598	2.59
Pipe (Conc.) per ft. f.o.b. Longview	(2)	$.85	1.20	1.50	1.75	2.00	2.50	2.85	3.50	4.40	5.50	6.10	.85
Hauling and distributing	(3)	.08	.12	.15	.18	.33	.44	.44	.83	.83	2.50	2.50	..08
Excavation, (1) x 0.60 - 12" to 24"incl. (1) x 1.60 - 27" to 54" "	(4)	.23	.24	.34	.31	.52	1.88	1.86	2.94	2.06	3.47	4.16	.16
Backfilling	(5)	.03	.03	.03	.03	.03	.10	.10	.10	.10	.10	.10	.03
Laying Pipe	(6)	.07	.08	.11	.15	.18	.24	.34	.43	.57	.70	.96	.07
Total labor; (3) to (6) inclusive	(7)	.41	.47	.63	.67	1.06	2.66	2.74	4.30	3.56	6.77	7.72	.34
Liability insurance and public liability; 6% of (7)	(8)	.02	.03	.04	.04	.06	.16	.16	.26	.21	.41	.46	.02
Total pipe laying; (7) and (8)	(9)	.43	.50	.67	.71	1.12	2.82	2.90	4.56	3.77	7.18	8.18	.36
Contractors Profit and overhead; 15%	(10)	.06	.07	.10	.11	.17	.42	.43	.68	.57	1.08	1.23	.05
Total cost laying pipe; (9) + (10)	(11)	.49	.57	.77	.82	1.29	3.24	3.33	5.24	4.34	8.26	9.41	.41
Total cost pipe laid; (2) + (11); dollars	(12)	1.34	1.77	2.27	2.57	3.29	5.74	6.18	8.74	8.74	13.76	15.51	1.26

Black & Veatch

Longview, Washington

Average, Maximum, and Minimum Precipitation in Inches by Months for the Period from 1900 - 1922 Inclusive.

	Astoria	Castle Rock	Kalama	Olympia	Portland	Rainier	Seattle	Vancouver
Jan.-Avg.	12.54	9.52	10.11	8.28	6.17	7.51	4.73	5.67
Max.	22.83	15.33	14.81	16.27	11.53	14.95	9.82	11.22
Min.	5.64	4.74	5.86	4.54	2.54	4.19	1.89	2.42
Feb.-Avg.	9.56	6.69	7.92	6.16	4.91	5.69	3.59	4.73
Max.	20.20	10.43	12.03	12.17	11.08	12.79	8.10	9.14
Min.	.65	.80	.84	.31	.16	.58	.34	.17
Mar.-Avg.	8.30	7.84	9.11	5.37	4.22	5.23	2.84	3.64
Max.	17.23	9.68	11.78	12.85	10.57	13.61	6.22	8.38
Min.	2.89	5.83	6.15	1.41	.63	1.59	.88	.70
Apr.-Avg.	4.92	4.24	6.49	3.24	2.90	3.39	2.13	2.61
Max.	10.73	5.18	10.43	7.24	5.58	5.21	4.48	5.03
Min.	.21	1.95	2.94	.71	.89	.01	.77	.76
May.-Avg.	3.77	3.97	2.59	2.41	2.13	2.71	1.78	2.16
Max.	6.88	8.45	4.09	5.34	3.95	4.67	3.73	4.40
Min.	1.32	1.84	1.89	.09	.59	1.21	.34	.64
June-Avg.	3.02	1.61	2.11	1.84	1.50	2.00	1.65	1.54
Max.	6.60	3.49	3.81	3.75	4.24	3.78	5.35	3.49
Min.	.53	.24	.14	.21	.12	.24	.03	.12(2)
July-Avg.	1.31	.51	.82	.94	.76	1.08	.65	.72
Max.	7.58	1.24	1.86	2.23	2.55	2.91	2.01	3.15
Min.	.04	.02	.07	.07	.01(3)	.13(2)	.01(2)	.02(2)
Aug.-Avg.	1.01	1.48	1.33	.67	6.90	.86	.54	.81
Max.	4.09	2.74	3.14	3.10	2.06	4.88	2.49	3.64
Min.	.02	.23	.02	.02	.01(2)	.01	.01	.03
Sept.-Avg.	3.48	3.59	4.31	2.37	2.00	2.29	1.62	2.08
Max.	8.66	7.70	9.31	5.24	5.19	5.25	3.39	4.88
Min.	.01	.11	.71	.19	.23	.27	.08	.16
Oct.- Avg.	6.05	4.72	5.36	4.49	2.70	3.63	2.66	2.79
Max.	12.80	7.79	10.31	9.10	5.17	5.73	4.37	5.14
Min.	1.08	.29	.69	.27	.03	.84	.16	.10
Nov.- Avg.	11.62	7.34	8.41	9.81	6.53	8.11	5.33	6.38
Max.	16.98	14.26	15.20	19.94	12.49	16.93	9.11	12.79
Min.	4.08	2.57	3.52	1.36	2.64	3.18	1.45	2.28
Dec.- Avg.	11.71	13.17	11.50	8.72	5.92	7.86	5.08	5.78
Max.	18.65	25.56	21.83	19.85	14.23	19.10	9.21	13.04
Min.	4.51	6.51	4.01	2.05	2.56	2.78	2.45	2.41

Longview, Washington.

Comparison of Total Precipitation in Inches by Years

from 1900 - 1922 Inclusive.

Year	Astoria	Castle Rock	Kalama	Olympia	Portland	Rainier	Seattle	Vancouver
1900	84.97			56.37	38.22		36.48	40.43
1901	77.87			55.09	41.05		30.18	40.56
1902	86.48			70.77	50.15	67.59	45.78	50.97
1903	74.86			56.88	35.62	50.12	34.55	34.25
1904	88.67			61.67	46.37	59.16	37.73	42.43
1905	72.63			46.43	34.10	38.60	34.35	33.30
1906	82.73			63.86	43.29	52.58	36.67	42.38
1907	73.91			51.68	42.89	48.19	29.10	39.86
1908	56.71			53.38	34.37	48.96	28.25	32.77
1909	69.42			61.24	43.75	56.45	31.72	44.24
1910	86.85			62.96	38.65	53.15	34.20	30.85
1911	59.17			39.39	33.28	39.38	21.69	30.85
1912	85.89			59.56	43.47	59.46	35.14	39.49
1913	71.29			43.66	36.30	44.23	24.59	33.36
1914	76.10			48.85	36.67	46.53	31.43	35.15
1915	79.23			40.64	41.30	49.51	33.83	52.27
1916	92.50			56.02	45.77	52.92	34.61	41.22
1917	66.05	31.98	76.04	54.55	40.50	52.06	28.90	34.34
1918	70.56	53.84	61.17		31.50	43.82	29.21	32.76
1919	81.76	63.27	67.56		45.70	47.61	31.34	41.28
1920	80.90	69.96	76.43	55.85	41.17	47.25	32.20	38.08
1921	93.69	73.75	75.72	59.77	43.21	58.67	38.81	39.71
1922	60.31	38.91	62.71	31.65	39.18	38.63	23.00	32.89

Black & Veatch


The Long-Bell Lumber Company
LONGVIEW, WASHINGTON
Waterworks Distribution System with Goble Creek Supply
WESLEY VANDERCOOK - CHIEF ENGINEER
BLACK & VEATCH - CONSULTING ENGINEERS
Scale:
400 0 400 800 1200 1600 2000 FT.
1923
LEGEND:
Size as noted Pipe Lines in place
Size as noted Cast Iron Pipe Lines
Hydrant
Valve
NORTH
Reservoir at elevation 275
Reservoir at elevation 125
OCEAN BEACH HIGHWAY
WEST KELSO
PENNSYLVANIA ST.
KELSO
COWLITZ RIVER
COLUMBIA RIVER
Future Extensions
Future Extensions
Temporary C.I. connection until Goble Creek line is constructed
Supply line from Goble Creek
Well Tower
CEDAR AVE.
BALTIMORE
BEECH
COLORADO ST.
CALIFORNIA WAY
BALTIMORE ST.
BEECH ST.
ARKANSAS ST.
ALDER ST.
COLUMBIA WAY
OREGON WAY
PACIFIC WAY
THIRD AVE.
MISSOURI
KESSLER
BOULEVARD
COMMERCE
DOUGLAS

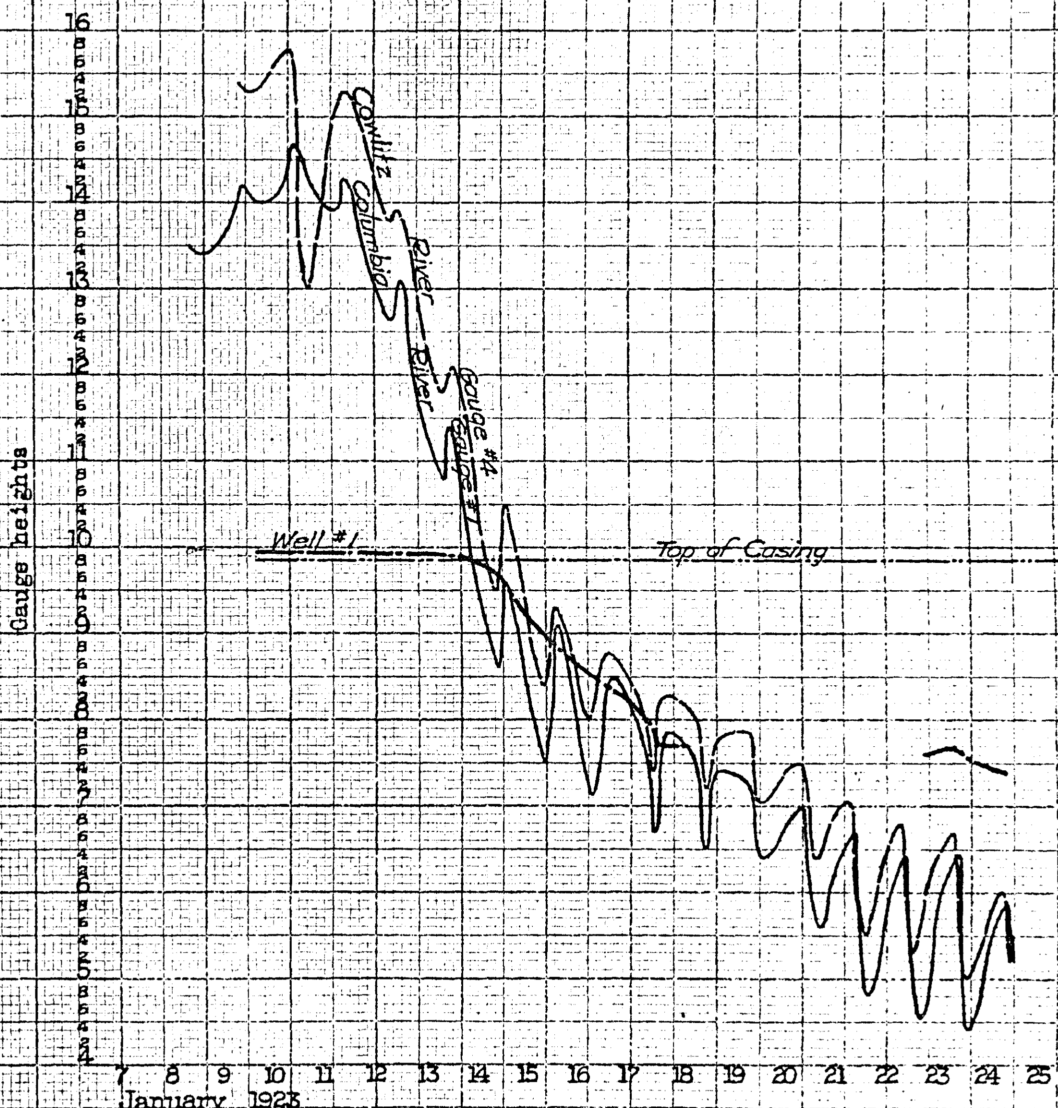
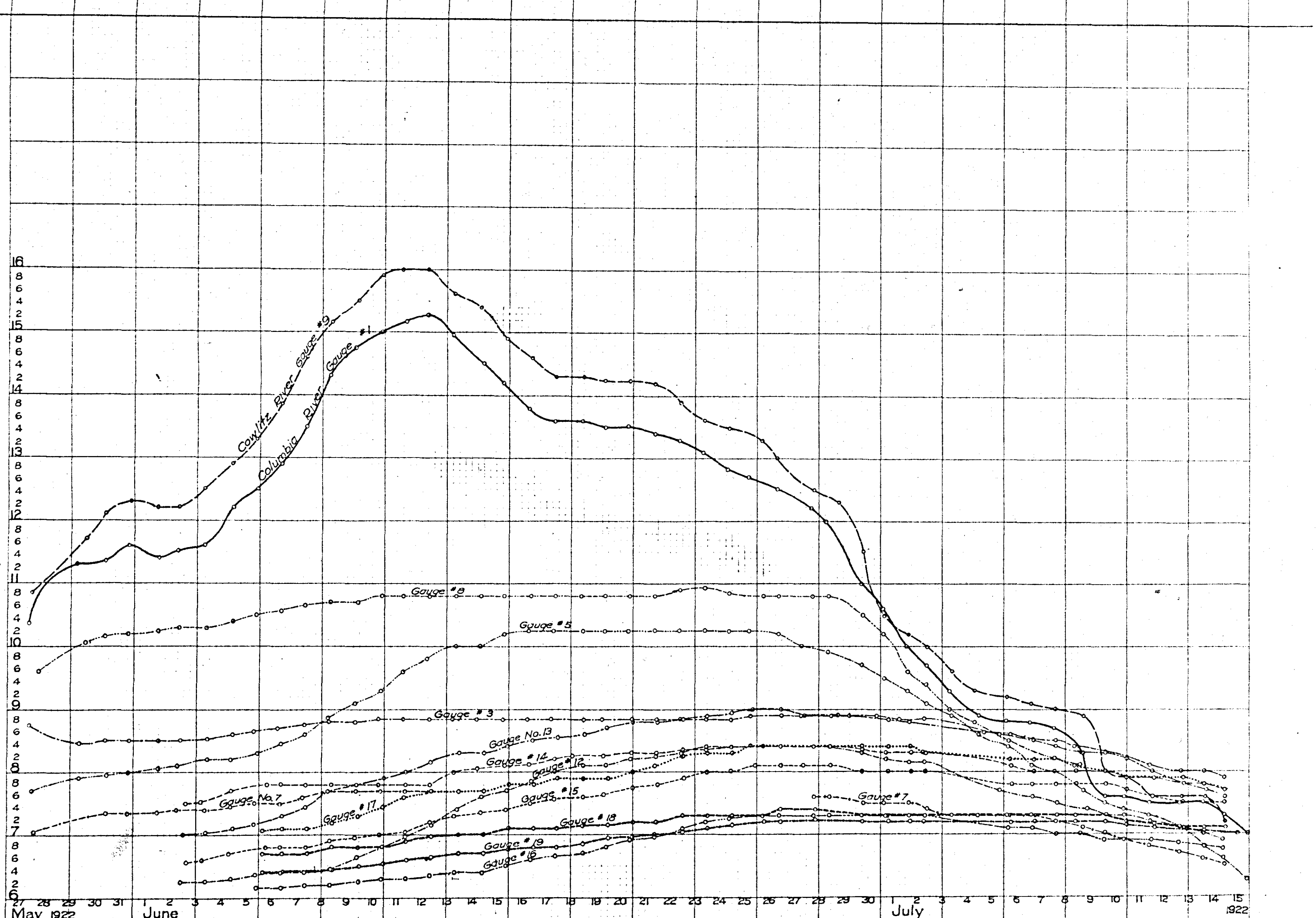


Chart Showing Comparative Elevations of Water in the Columbia and Cowlitz Rivers, and Well Number One, near Eighteenth Avenue and Baltimore Street, Longview, Washington.

To accompany Longview, Washington, Water Supply & Distribution Report
Black & Veatch
1923

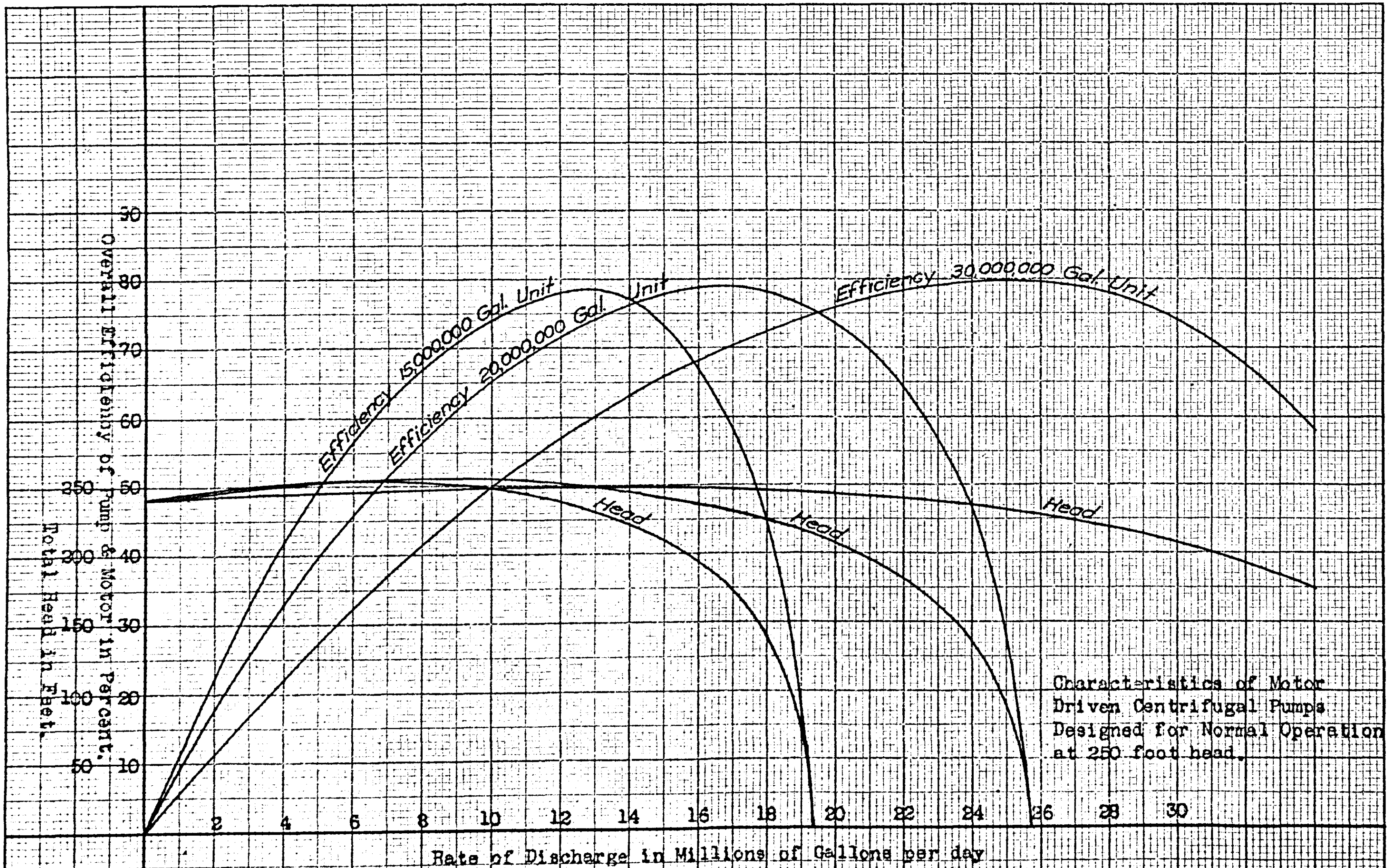


LONGVIEW, WASHINGTON

Chart Showing Effect of Columbia and Cowlitz River Stages on Ground Water Elevations at Points in Longview Townsite

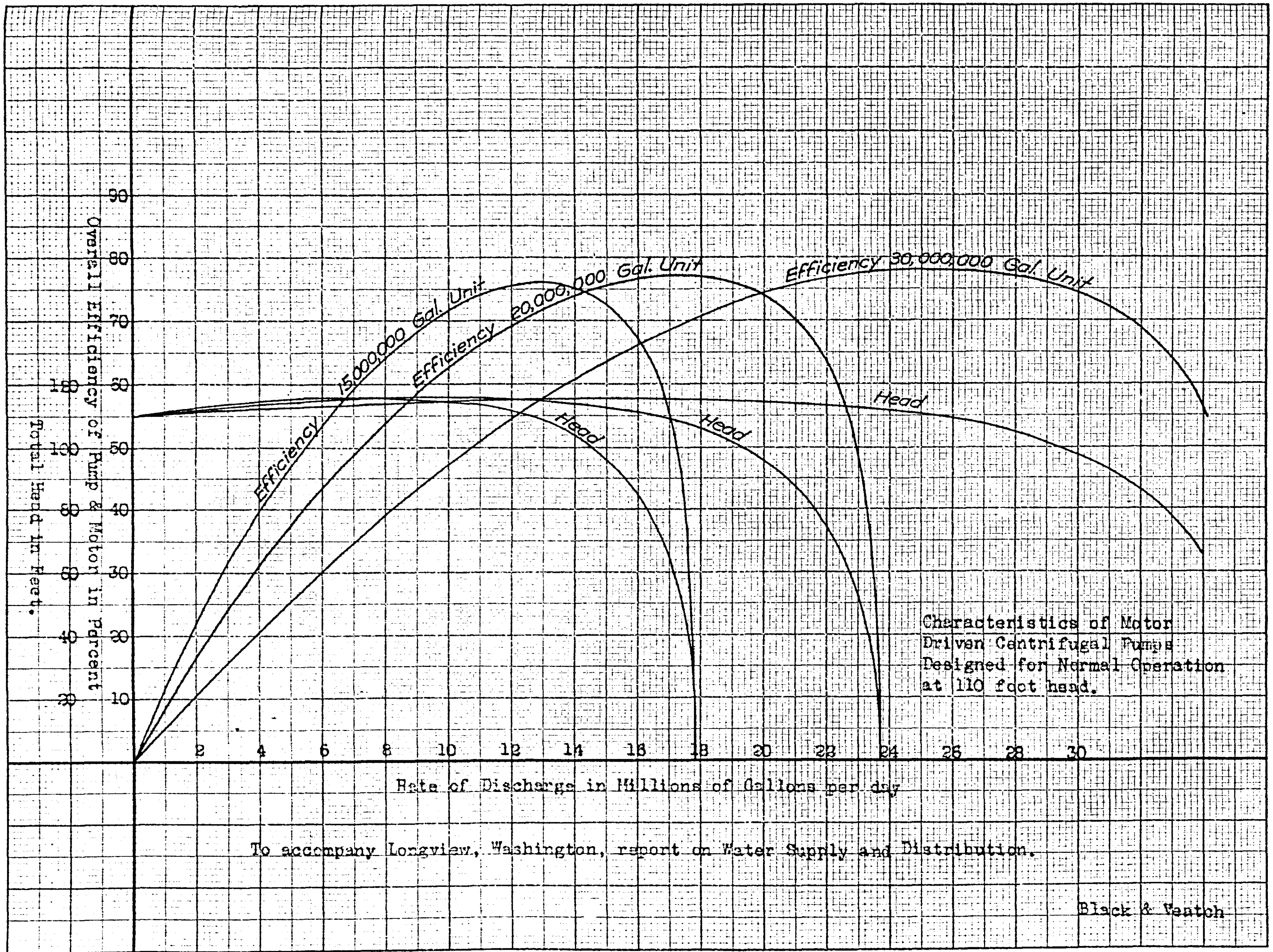
Black & Veatch - Consulting Engineers
1923

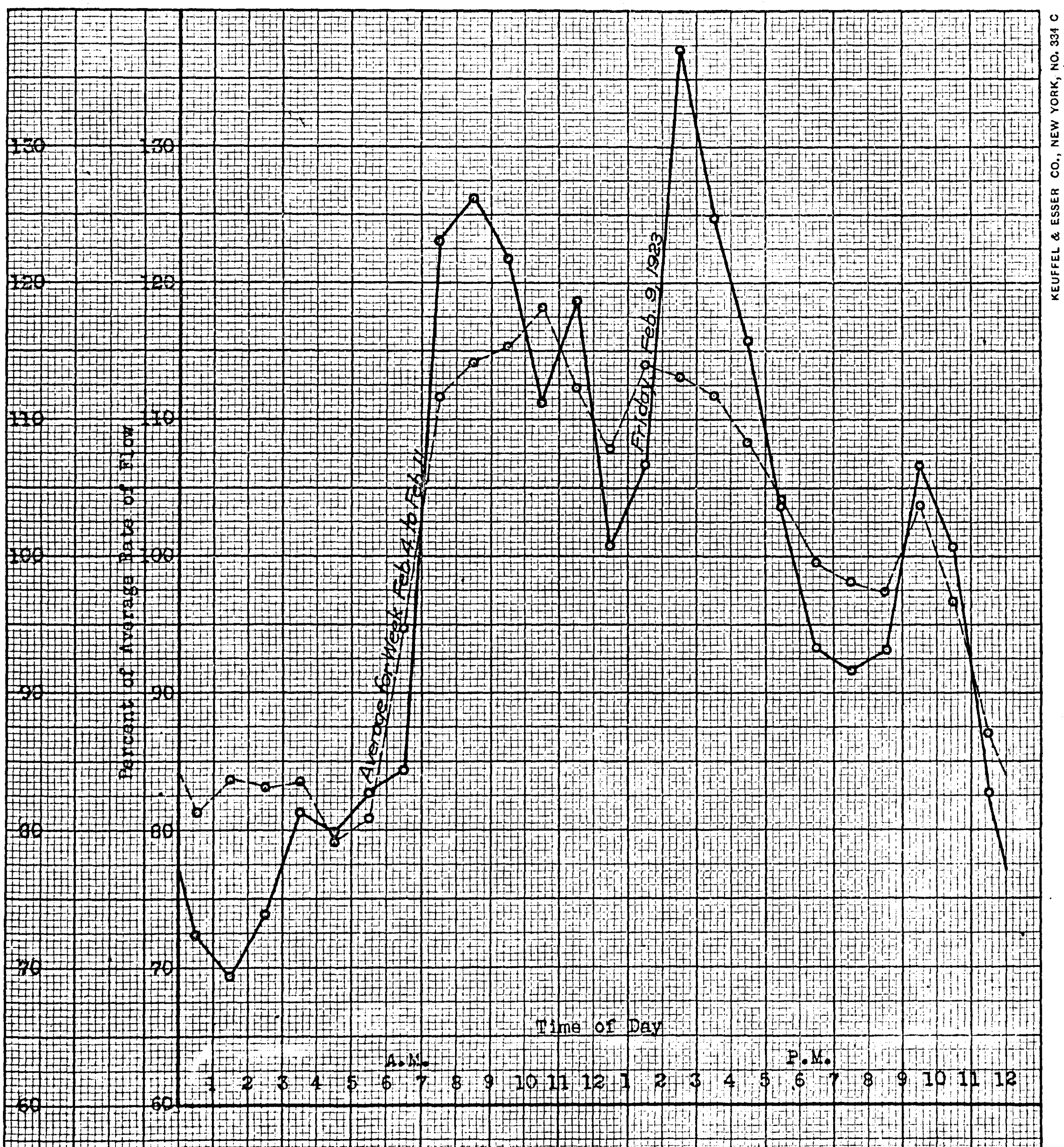
Data from which this chart is compiled was collected by the Engineering Department of the Long-Bell Lumber Company



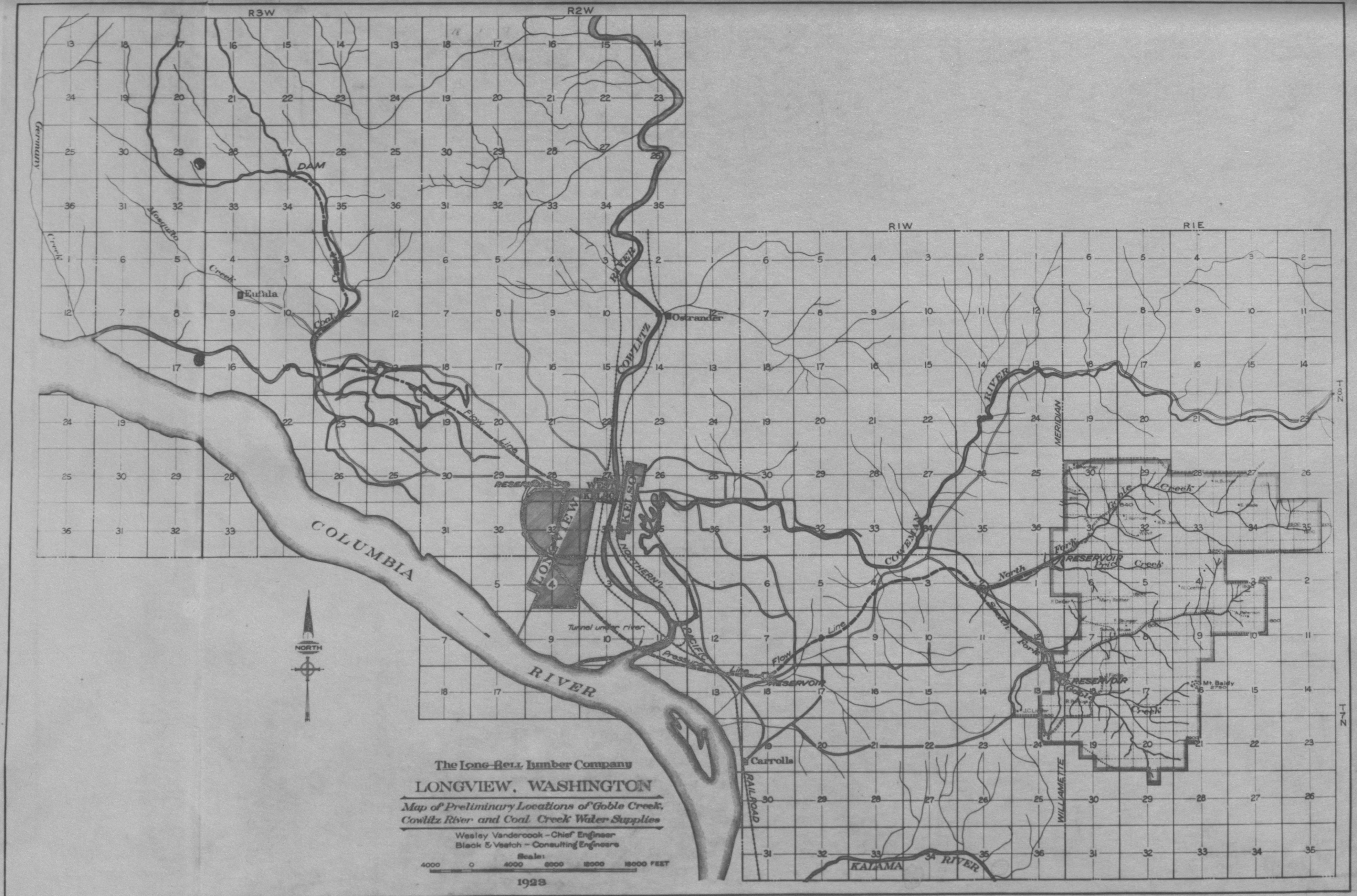
To accompany Longview, Washington, report on Water Supply and Distribution.

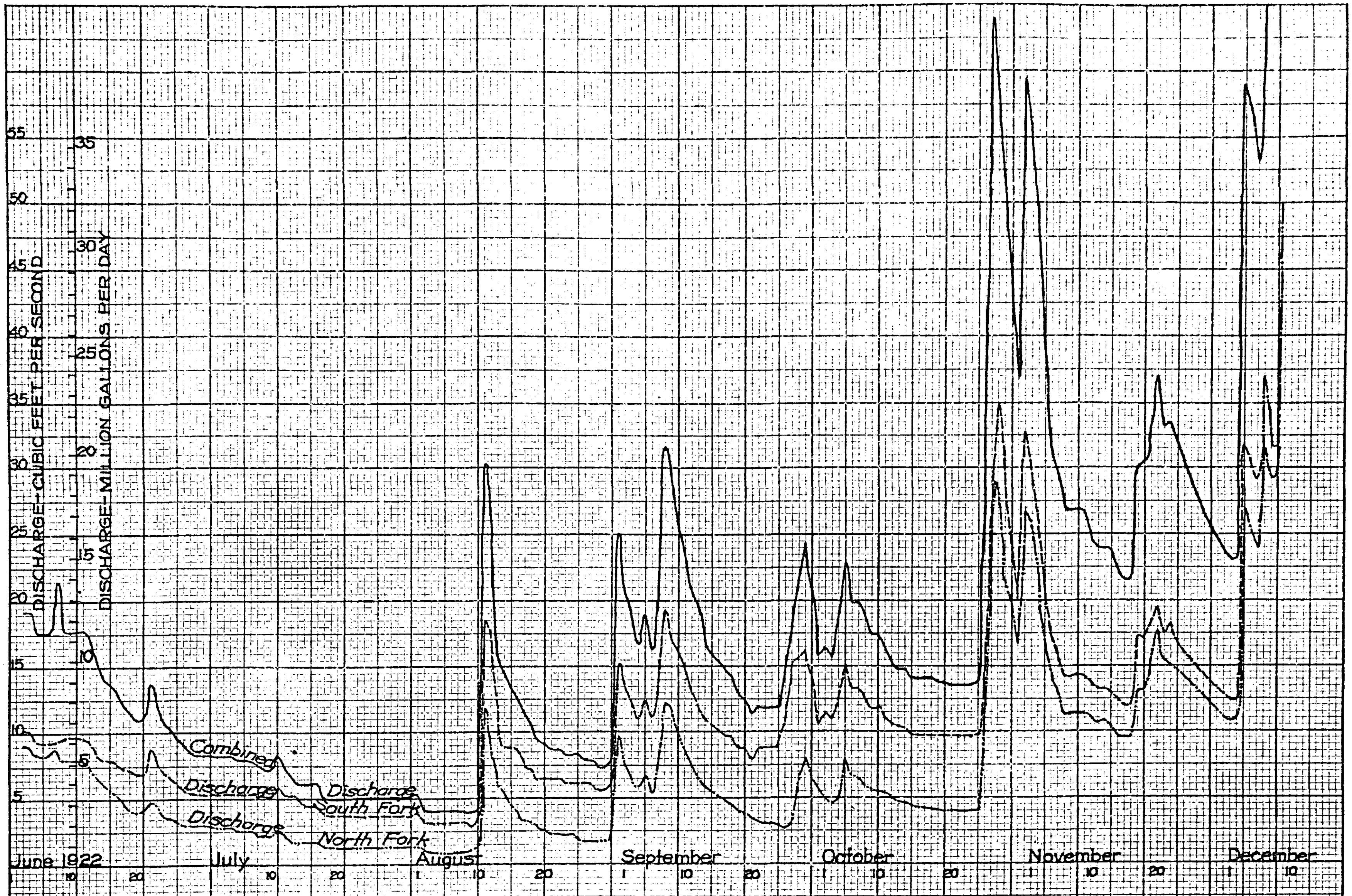
Black & Veatch


Overall Efficiency of Pump & Motor in Percent
Total Head in Feet.
90
80
70
60
50
40
30
20
10
120
100
80
60
40
20
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Rate of Discharge in Millions of Gallons per day
Efficiency 15,000,000 Gal. Unit
Efficiency 20,000,000 Gal. Unit
Efficiency 30,000,000 Gal. Unit
Head
Head
Head
Characteristics of Motor
Driven Centrifugal Pumps
Designed for Normal Operation
at 110 foot head.
To accompany Longview, Washington, report on Water Supply and Distribution.
Black & Veatch

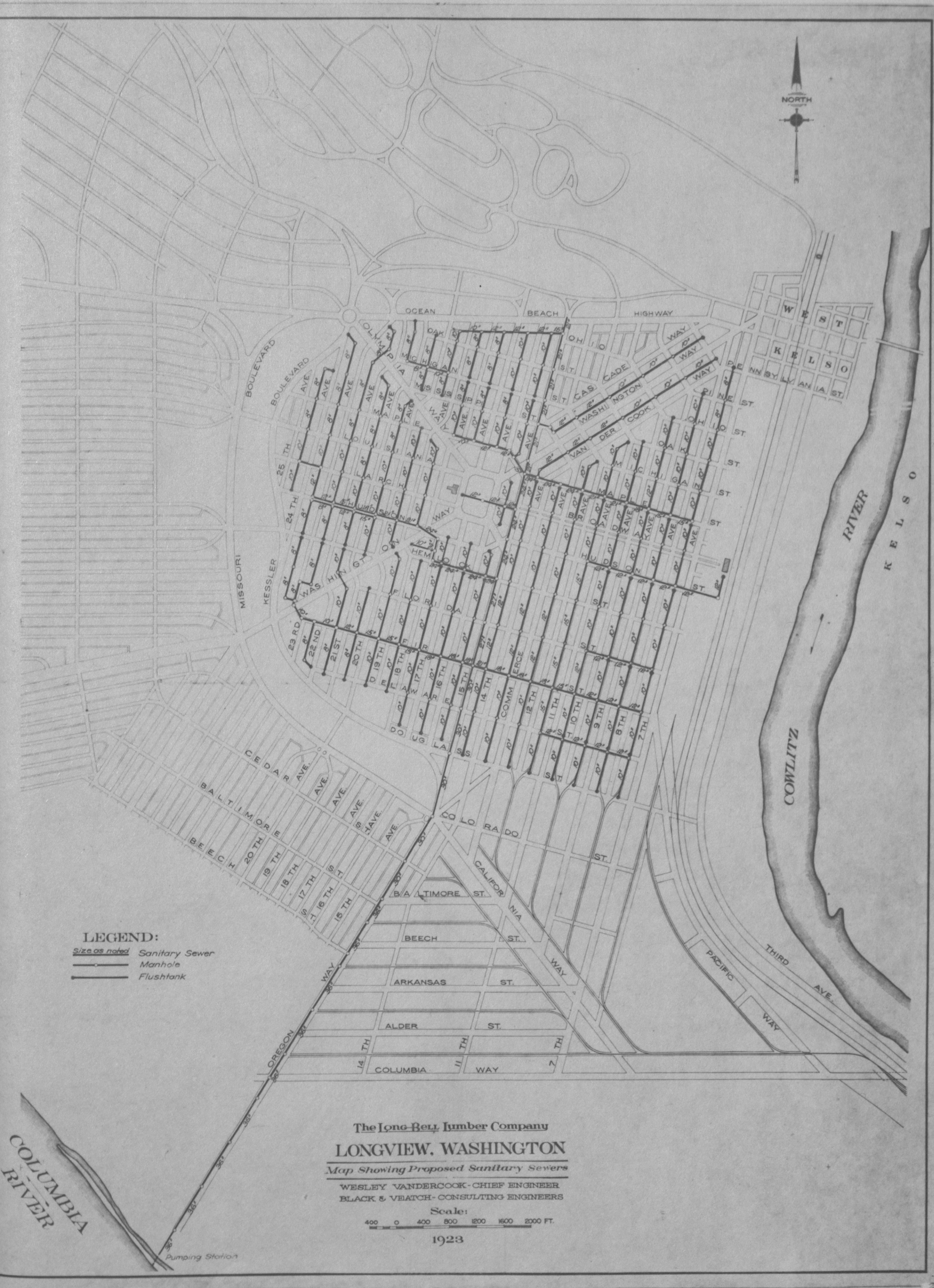


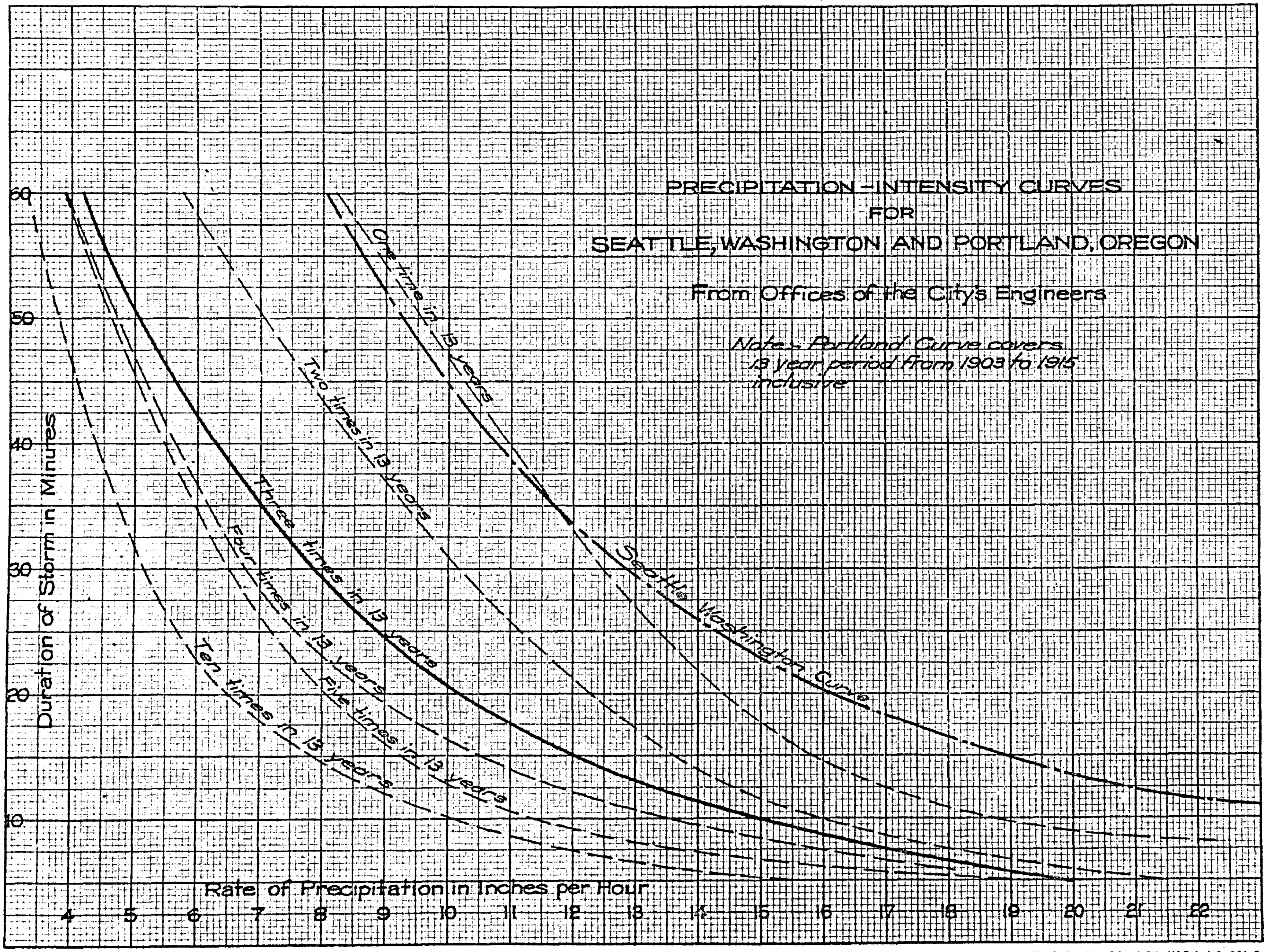
Comparetive Hourly Demand Rates
Topeka, Kansas, Direct Pressure Waterworks System
For February 4, 5, 7, 8, 9, 10, & 11, 1923
To accompany Longview, Washington, Water Supply & Distribution Report
Black & Veatch,
1923


The Long-Bell Lumber Company
LONGVIEW, WASHINGTON
Map of Preliminary Locations of Goble Creek, Cowlitz River and Coal Creek Water Supplies
Wesley Vandercook - Chief Engineer
Black & Veatch - Consulting Engineers
Scale:
4000 0 4000 8000 12000 16000 FEET
1923
R3W
R2W
R1W
R1E
T8N
T7N
COLUMBIA RIVER
COWLITZ RIVER
KALAMA RIVER
COWEEMAN RIVER
LONGVIEW
KELSO
DAM
Eufala
Ostrander
Carrolls
Germany Creek
Mosquito Creek
Coal Creek
Goble Creek
North Fork
South Fork
RESERVOIR
Flow Line
Pressure Line
Tunnel under river
NORTHERN PACIFIC RAIL ROAD
WILLAMETTE MERIDIAN
NORTH
Mt. Baldy



Discharge from North and South Goble Creeks - June 2 to December 9, 1922, inclusive.
To accompany Longview, Washington, Water Supply & Distribution Report
Black & Veatch
1923


LEGEND:
Size as noted — Sanitary Sewer
Manhole
Flushtank
NORTH
The Long-Bell Lumber Company
LONGVIEW, WASHINGTON
Map Showing Proposed Sanitary Sewers
WESLEY VANDERCOOK - CHIEF ENGINEER
BLACK & VEATCH - CONSULTING ENGINEERS
Scale:
400 0 400 800 1200 1600 2000 FT.
1923
COLUMBIA RIVER
COWLITZ RIVER
KELSO
WEST KELSO
OCEAN BEACH HIGHWAY
OREGON WAY
CALIFORNIA WAY
PACIFIC WAY
THIRD AVE.
COLUMBIA WAY
BALTIMORE ST.
BEECH ST.
ARKANSAS ST.
ALDER ST.
COLORADO ST.
MISSOURI
KESSLER BOULEVARD
CEDAR AVE.
BALTIMORE
BEECH
Pumping Station


PRECIPITATION - INTENSITY CURVES
FOR
SEATTLE, WASHINGTON AND PORTLAND, OREGON
From Offices of the City's Engineers
Note:- Portland Curve covers 13 year period from 1903 to 1915 inclusive
Duration of Storm in Minutes
60
50
40
30
20
10
Rate of Precipitation in Inches per Hour
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
One time in 13 years
Two times in 13 years
Three times in 13 years
Four times in 13 years
Five times in 13 years
Ten times in 13 years
Seattle, Washington Curve


NORTH
OCEAN BEACH HIGHWAY
WEST KELSO
PENNSYLVANIA ST
PINE ST
OHIO ST
OAK ST
MICHIGAN ST
MAPLE ST
BROADWAY
HUDSON ST
HEMLOCK
WASHINGTON
FLORIDA
FIR ST
DELAWARE
DOUGLASS ST
COLORADO ST
CASCADE WAY
VANDERCOOK WAY
MISSISSIPPI
OLYMPIA WAY
BOULEVARD
Lake
Fowler
MISSOURI
KESSLER
COMMERCE
DRAINAGE DITCH
PROPOSED Power Lane
COWLITZ RIVER
KELSO
CEDAR AVE.
BALTIMORE
BEECH
BALTIMORE ST
BEECH ST.
ARKANSAS ST.
ALDER ST.
COLUMBIA WAY
CALIFORNIA WAY
OREGON WAY
PACIFIC WAY
THIRD AVE
COLUMBIA RIVER
LEGEND:
Size as noted Storm Sewer
Manhole
Storm Water Inlets
The Long-Bell Lumber Company
LONGVIEW, WASHINGTON
Map Showing Proposed Storm Sewers
WESLEY VANDERCOOK - CHIEF ENGINEER
BLACK & VEATCH - CONSULTING ENGINEERS
Scale:
400 0 400 800 1200 1600 2000 FT.
1923

Longview, Washington

Instructions to Bidders,

Preliminary Estimate of Quantities,

Proposal, Specifications & Contract.

for

Water Distribution

1923

Longview, Washington

INSTRUCTIONS TO BIDDERS ON WATER MAINS CONSTRUCTION

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(1) Sealed bids will be received by The Long-Bell Lumber Company, Longview, Washington, up to ________ o'clock ___M., ______________________________ 1923, and then opened, for furnishing all labor, equipment, tools, and such materials as are not specified to be furnished by The Long-Bell Lumber Company, and constructing water mains in Longview Townsite, in accordance with plans, profiles and specifications on file in the office of the Chief Engineer of the Company.

(2) Plans may be examined and the forms on which all bids shall be made, may be obtained at the office of the Chief Engineer. Bidders may obtain plans for their own use by making a deposit of ______________________; ________________ ____________ of which amount will be refunded on the return of the plans; ______ ________________________ being retained to cover cost of printing.

(3) When filed, bids shall be enclosed in a sealed envelope, addressed to The Long-Bell Lumber Company, marked on the outside with the name and address of the bidder, and shall be accompanied by a certified check on a Kelso, Washington, bank, or by a Cashier's check on any bank, in an amount approximating five per cent (5%) of the amount of the bid, provided that no check for less than $________ or more than $__________ shall be filed. All checks shall be left in the hands of the Company as a guarantee that the bidder will, if the contract is tendered him, enter into contract and furnish the required bond within the time specified in the annexed proposal. Checks of unsuccessful bidders will be returned when their bids are rejected. Checks of successful bidders will be returned when the contracts have been signed, and the required bond furnished and approved by the Company's attorneys.

(4) Bidders shall fill in all blanks on the bidding forms; when firms bid, names of theindividual members shall be given in full, and the firm name added, The place of residence of each bidder shall be given. Each bidder shall state in his proposal the date on which he proposes to complete the work is the contract is awarded him. None of the instructions to bidders, bidding forms, estimate of quantities, specifications or contract shall be detached from the bound copy before filing with the Company. All bids will be compared on the basis of the Engineer's preliminary schedule of quantities.

(5) The successful bidder, before starting construction, will be required to give bond in the full amount of the contract, with a surety company authorized to do business in the State of Washington, and acceptable to the Company as surety.

(6) All bidders shall examine for themselves the location of the proposed work, and the nature of the excavation to be made.

(7) Payment for the improvement will be made in cash; the Engineer will prepare monthly estimates on which eighty-five (85) per cent will be paid on or about the first of each month, fifteen per cent being retained until the completion, final inspection and acceptance by the Company of the work contracted.

(8) The Company reserves the right to reject any or all bids, or waive defects in bids.

Longview, Washington.

ENGINEER'S PRELIMINARY SCHEDULE OF QUANTITIES

FOR CONSTRUCTION OF WATER MAINS AND APPURTENANCES.

PROPOSAL FOR WATER MAIN CONSTRUCTION

TO THE LONG-BELL LUMBER COMPANY,
LONGVIEW, WASHINGTON.

GENTLEMEN: Having examined the plans, specifications and contract, and being fully informed relative to the location, character and extent of the work to be performed in connection with the construction of water mains in Longview Townsite, the undersigned hereby propose to furnish all labor, equipment, tools and such materials as are not specified to be furnished by the Company, and construct complete water mains, in accordance with the detailed plans, specifications and contract on file in the office of the Chief Engineer, at the following prices, to-wit:

ITEMS	PRICE IN WORDS	PRICE IN FIGURES
For furnishing all labor, equipment, tools and materials not specified in the attached specifications to be furnished by the Long-Bell Lumber Company, transporting to the site of the work, all pipe, special castings, valves, hydrants, and miscellaneous materials, from stock piles, warehouses, or at other specified points of delivery by The Long-Bell Lumber Company, excavating for, placing pipe, special castings and valves and back-filling all mains and appurtenances as spefified, at the following prices, viz:		
For 6" cast iron pipe lines, per lin. ft.,	________	($______)
" 8" " " " " " " "	________	($______)
" 10" " " " " " " "	________	($______)
" 12" " " " " " " "	________	($______)
" 14" " " " " " " "	________	($______)
" 16" " " " " " " "	________	($______)
" 18" " " " " " " "	________	($______)
" 24" " " " " " " "	________	($______)
" setting hydrants - each	________	($______)

The undersigned hereby agrees to furnish the required bond and to enter into contract within ten days from the date of your acceptance of this proposal to finish and complete the work covered by this bid on or before________________________ ________________________. If this proposal is accepted, and should________ for any reason fail to furnish the required bond and sign the contracts within ten days as above stipulated, the check which has been this day deposited with the Long-Bell Lumber Company, shall at the option of the Company be absolutely forfeited to the Long-Bell Lumber Company, but otherwise the check shall be returned to the undersigned on the signing of the contract and approval by the Company of the contract bond.

DATED AT LONGVIEW, WASHINGTON, This______day of________________A.D. 1923.

NAMES	ADDRESSES
________________________	________________________
________________________	________________________

Longview, Washington

SPECIFICATIONS AND CONTRACT FOR THE CONSTRUCTIONS OF

WATER MAINS AND APPURTENANCES.

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1. These specifications, together with the attached "Instructions to Bidders", "Preliminary Schedule of Quantities", "Proposal", and "Contract", together with the plans and profiles for this improvement now on file in the office of the Chief Engineer of The Long-Bell Lumber Company, such special specifications and plans as may be necessary from time to time during the progress of the work, and the laws of the State of Washington controlling and limiting contract operations of this nature, all taken as a whole, shall constitute the contract under which the specified improvements shall be executed.

2. DEFINITION OF TERMS: Whenever the term "Company" appears in the "Instructions to Bidders", "Schedule of Quantities", "Proposal form", "Specifications", or "Contract", or on the plans, it shall be understood to mean the Long-Bell Lumber Company, the party of the first part as incorporated and operating under the laws of the State of Missouri and admitted to operate in the state of Washington. The term "Engineer" shall mean the Chief Engineer of the Long-Bell Lumber Company, or his duly authorized agents. The term "Contractor" shall mean the second party to the contract.

3. EXAMINATION OF GROUND: Bidders must examine and judge for themselves the location of the proposed work and the nature of the excavation to be made. The plans, profiles and other drawings for the work show conditions as they are supposed and believed to exist, but it is not intended that the conditions as shown by the plans and profiles constitute a representation of the Company, or of its officials or agents that such conditions actually exist. Neither shall the Company nor any of its officers or agents be liable for loss sustainted by the Contractor as the result of variance between the conditions as shown by the plans and profiles and the actual conditions revealed during the progress of the work.

4. EXPLANATORY NOTES OR FIGURES: Explanatory notes or figures on plans shall take precedent over scaling, and any discrepancy or misunderstanding concerning plans or specifications shall be decided by the Engineer, whose decision shall be taken as final and conclusive. Prior to submitting a proposal on work the Contractor shall take up with the Engineer items not clearly understood, or items which may later form the basis of a misunderstanding. The work herein described is to be completed in every detail notwithstanding that every item involved is not specifically mentioned.

5. MATERIALS FURNISHED BY COMPANY: It is the intent of the specifications that the contractor shall furnish for the price bid, all labor, equipment, tools, and machinery required for the complete performance of this contract in full accordance with the plans and specifications. The company will furnish all cast iron, steel and lead pipe, all cast iron and malleable fittings, specials, manhole covers and fittings for valve manholes, valves, hydrants, stop cocks, corporation cocks, goose necks, lead, jute, brick, cement, sand, stone, gravel,

and all other materials necessary excepting lumber, nails, jacks or other special materials or equipment used for timbering, sheeting, bracing, and pumping water from excavations for water mains, appurtenances and structures. The contractor shall transport to the site of the work from warehouses, yards, wharves, or other specific locations named at the time of entering into this contract, all materials furnished by the Company, without charge other than is included in the unit prices bid.

6. CEMENT: (a) Cement shall be first-class Portland Cement, and shall meet the current specifications of the American Society for Testing Materials. It shall be well packed and the brand and name of the manufacturer plainly marked on the barrel or sack. It shall be fresh and properly seasoned. All cement furnished the Contractor by the Company will be subject to inspection at any time up to its use in the work, and if found to be of improper quality will be branded and must be immediately removed from the work. The Contractor shall submit the cement for inspection, giving sufficient time for testing before any part of it is used in the work.

(b) The Contractor shall at all times keep in store sufficient quantities of cement to allow time for tests without delay to the work of construction. The cement must be stored in a tight building and all sacks must be raised from the ground.

7. SAND: Sand shall consist of "sharp" grains from hard, tough, durable rocks, and shall be free from clay, loam or organic matter, not more than five (5) per cent of it shall pass a #200 seive.

8. STONE: (a) The stone for concrete shall be of best quality of hard trap-rock or granite boulders. It shall be free from mud, dirt, dust, loam or other objectionable material. When the Engineer shall order, it shall be screened to remove dust.

(b) All broken stone used in reinforced concrete work shall pass a one (1) inch ring with its greatest dimension. Broken stone used in foundations or unreinforced walls shall pass a 2-1/2 inch ring with its greatest dimension, and if necessary, stone shall be screened to conform to these sizes.

9. BRICK: All brick used in manholes shall be of uniform texture, hard burned entirely through, free from lime or other impurities that will affect them in air or water.

10. PROPORTIONING CONCRETE BY PARTS: In proportioning concrete by parts, the standard bag of cement weighing not less than ninety-four (94) pounds net, shall be taken as one cubic foot; sand and stone shall be measured accurately from a box prepared for that purpose, to determine the proper point to which wheel-barrows shall be filled, and the depth of filling shall be indicated by marks on the inside of the barrows.

11. CEMENT MORTAR: (a) All cement mortar for brick work shall be made of one (1) part of cement and three (3) or sand. Limewater may be used to temper the mortar for brick work, but the lime shall not replace cement and the amount of

lime shall not exceed fifteen per cent, by weight, of the amount of the cement.

(b) In mixing mortar, cement and sand shall be thoroughly mixed dry and such quantity of water added as is necessary to form a paste of proper consistency. All mortar shall be fresh for the work at hand; mortar that has begun to set will be thrown away. All mixtures shall be made by actual measurements.

12. CONCRETE: (a) The concrete used in reinforced concrete shall be made of one part cement, two parts of sand, and four parts of broken stone. The cement content per cubic yard of finished concrete shall not be less than 1.5 barrels for 1-2-4 concrete or 1.15 barrels for 1-3-5 concrete.

(b) All concrete shall be machine mixed except in the case of concrete for manholes or other isolated small structures where hand mixing will be allowed. At all times the methods followed in machine and hand mixing, and the type of equipment used, shall be subject to the approval of the Engineer. Concrete shall be thoroughly mixed of such a consistency that it flows well in forms, but shall not be so wet that aggregate will separate out. It shall be used immediately after mixing. On approval of the Engineer, bed gravel may be used for concrete work. In the event that gravel is used instead of stone, the Engineer shall determine the proper proportions of cement and sand to be used, after the gravel is delivered to the site of the work. The right is reserved to change the proportions of rock or sand at any time to secure a tight concrete.

(c) No concrete shall be mixed or placed in the work when the temperature is below 32° Fahr., and the Contractor shall use such methods to protect finished concrete from freezing, before it has thoroughly set, as may be necessary.

13. REINFORCING STEEL: Reinforcing steel shall fulfill the latest specifications of the American Society for Testing Materials for what are known as round deformed rail steel concrete reinforcing bars or billet steel concrete reinforcing bars.

14. FORMS: (a) All forms for concrete shall be constructed by experienced carpenters, and shall be built and braced in such a manner that they will not go out of line when concrete is deposited in them.

(b) The forms for all walls should preferably be such as to allow continuous pouring the full height of the wall. Especial care shall be used to have tight forms for all of the walls.

(c) Forms shall not be removed until the concrete has set sufficiently to carry any load which may be thrown on it by such removal. The lengths of time required shall be subject to the approval of the Engineers.

15. PROTECTION OF PROPERTY; (a) The Contractor shall at his own expense shore up, protect and insure from injury, all buildings, walls, fences, pavements, curbs, trees, sewers, water mains, service pipes, lamp posts, drains, and all other structures which may be met with in carrying out the work. In case any of those are removed during the work, they shall be replaced by the Contractor at his own expense in as good condition as they were before being removed, and

in case of his refusal to make such repairs, they shall be made by the parties having control of the same, and the expense shall be deducted by the Company from the amount which may be due or become due the Contractor.

(b) The Contractor shall erect suitable barriers around all excavation and materials piled in the streets, alleys, or highways, to prevent accidents to pedestrians, animals or vehicles, and shall place and maintain during the night, sufficient red lights on or near all work to properly warn pedestrians and persons in vehicles of danger.

(c) The Contractor shall give notice in writing at least twenty-four hours before breaking ground, to all persons (Superintendents, Inspectors and Agents) in charge of the streets, alleys, or highways, water mains, railroads or other property, that may be affected by his operations; and the Contractor shall not cause any hindrance to or interference with any such person, persons, Company or Companies in protecting their property, but said Contractor shall permit the said person, or persons, Company or Companies to take such measures as they deem necessary for the purpose aforesaid.

(d) All railroad tracks and track structures crossing the line of the mains shall be supported by the Contractor during construction under or near them; the work shall be so prosecuted as to not interrupt the use of the tracks or endanger the traffic on them, and such tracks and track structures shall be restored full to their original condition.

(e) Should any sewers, conduits, or other underground construction be encountered on the same level as the water mains, the Contractor shall raise or lower the water mains under the direction and to the satisfaction of the Engineer, and shall be paid therefor as provided under "Extra Work" in the Contract.

(f) The Contractor shall observe all the City ordinances and State laws in relation to obstructing streets, alleys and highways, keeping open passageways and protecting the same where exposed, and generally obey all ordinances, rules and regulations controlling or limiting those engaged on construction work.

(g) At the suspension of any work the trenches shall be filled and streets or roadways left clean and free for travel.

16. PIPE AND SPECIALS: (a) The cast iron pipe and specials furnished by the Company, will conform in every particular to the specifications of the "American Water Works Association" for Class "C" pipe and Class "D" standard special castings. The weight of Class "C" pipe is approximately as set forth in the following tabulation.

	Weight in poinds per foot	
Size of Pipe	12' lengths	16' lengths
6"	35.8	35.0
8"	52.1	50.9
10"	70.8	69.4
12"	91.7	90.0
14"	116.7	
16"	143.8	
18"	175.0	
20"	208.3	
24"	279.2	

(b) The Contractor will be required to cut pipe, either for removing defective ends, or for making connections at fixed points, with no additional charge over the price per foot named in the proposal. All unused pile sections, scrap and specials, remains the property of the Company and on completion of a line of pipe, shall be salvaged and placed in stock piles or warehouses when and as directed by the Engineer.

17. LOCATION AND GRADE OF MAINS AND APPURTENANCES: Pipe lines, specials, valves, hydrants, and valve manholes, shall be located as shown on the plan of the work, and will be staked out by the Engineer in advance of the Contractor's requirements. The line for trenches will be indicated by stakes set at one side of the trench. Pipe lines shall be paid approximately parallel to the finished grade of the alley or street in which they are located, and they shall normally be laid at such depths that pipe will have____________inches of cover. Hydrant connections from the main to the hydrant shall be graded to give the same approximate cover over the hydrant connection at the hydrant, as that over the main. When necessary to lay one line at a greater depth than another on account of difference in the grade of streets or alleys where pipe lines intersect or to secure a specified cover over the larger main, where pipe lines of different sizes join, the Contractor shall do the additional excavation required without extra expense. In no case shall mains be so laid that air pockets will collect in them between hydrants or two cross feeders.

18. EXCAVATION AND BACKFILLING: (a) In order to provide room for properly lining, grading and jointing pipe lines and specials, trenches shall be not less than twelve (12) inches wider than the outside diameter of the pipe, and at specials, valves and hydrants, the trench shall be of such additional width and depth that calkers can work entirely around the joints.

(d) The bottoms of all trenches shall be graded so pipe will rest approximately along the entire length of each joint excepting at "bell holes", where greater depth is necessary for jointing and calking.

(c) When backfilling, bell holes must first be filled and thoroughly tamped, in layers of not more than six inches, up to a depth of six inches above the bell, and for at least two feet on either side. Backfilling shall be similarly done along the sides and up to the top of the pipe barrel. The remainder of the pipe may be filled with scrapers and flooded, excepting that at cross walk, street and alley crossings, backfilling shall be tamped to the surface.

19. LAYING CAST IRON PIPE: (a) Before lowering joints of pipe into the trench they shall be subjected to the hammer test or any other test the Engineer shall deem necessary. Any pipe found to be defective will be rejected. The Contractor shall swab the inside of each pipe or special prior to placing it in the line in order to clean the pipe. The method employed shall thoroughly remove all accumulations in the pipe without damage to the coating.

(b) Should the Contractor scrape or remove the inside or outside coating of pipe or specials, he shall paint the abraded spots with asphaltum paint, the quality and method of application of which shall at all times be subject to the Engineer's approval.

(c) After placing pipe and special castings in the trench they shall be lined, brought to an approximate uniform grade upon the solid trench bottom and the spigot adjusted in the socket, after which earth shall be tamped at points along the sides of the joint of pipe or specials to hold it in place before pouring the joint. The spigots of the pipe shall be so adjusted in the sockets as to give uniform space all around, and if any pipe or special does not allow sufficient space, it shall be replaced by one of the proper dimensions. The annular clearance of the joint shall at all points be at lease five-sixteenths (5/16) of an inch in thickness.

(d) Only lead and jute joints may be used. The depth of lead shall be such as to fill a space back of the bell groove an amount not less than three fourths (3/4) inch in depth. Gaskets of clean, sound jute, braided or twisted, and tightly calked, shall be used to pack these joints. The lead used shall be of the best quality of pure soft lead suitable for calking and securing a tight and permanent joint. Before running the lead, joints shall be carefully wiped out to make them clean and dry; the joints shall be run full at one pouring, and the melting pot shall always be kept within fifty (50) feet of the joint about to be poured. As provided for under "Excavation and Backfilling", bell holes of sufficient size for calking must be provided and must be kept free from water while pouring the joint.

(e) Each joint shall be well calked by competent mechanics, in such a manner as to secure a tight joint without overstraining the iron of the bell. In all cases the calking shall be done toward the "gate" and other joints where the lead is likely to be porous, so as to drive it together at these points. The lead, after being driven, shall be flush with the face of the sockets. The open ends of all pipe lines shall be plugged with temporary plugs on leaving the work at night.

(f) At all bends in pipe lines atthe end of any run, and at points where branch lines start from a tee, blocking or anchoring shall be provided. In ditches exacavated in clay or in well confined dry coarse sand, blocking with concrete blocks will be used, the area of bearing surface of the block used corresponding to the following table.

Size of pipe Branch	Area of Bearing Surface of Block in square feet.	Size of collar or sling and turn-buckle, in square inches of cross-section.	*Size of cable 2 Reqd.
6"	3	0.25	3/8"
8"	3	0.35	3/8"
10"	5	0.55	1/2"
12"	7	0.80	1/2"
14"	9	1.20	5/8"
16"	12	1.50	3/4"
18"	15	2.00	1"
20"	19	2.30	1"
24"	27	3.00	$1\frac{1}{4}$"

*"Copperweld" strand 19 wire, or equivalent.

For hydrant connections, a block of the size specified for 6" branches shall be built back of the hydrant and back of the tee in the line, on pipe lines 12" or less in size. For ordinary tee branches blocks of the size corresponding to the branch line shall be built back of the tee in the run. At ends and bends in lines blocks shall be the size shown in the table for corresponding sizes of pipe. If the area of the bearing surface of the block exceeds the bearing surface projection of the fittings, the block shall be built as a trancated pyramid; the bearing surface at the tee corresponding to the projection of the tee between bell ends, and the bearing surface on the side of the ditch, to the area shown in the table. A block need not be placed back of a tee if the branch line is not over one fifth the area of the main, except where the tee is at the end of the run.

(g) Concrete used in the blocks shall be of quality corresponding to the ordinary 1:3:5 sand, stone concrete. No block shall be less than one feet thick. For all plugs on lines that will be extended in the future, and at all locations where the excavation is in water bearing or soggy soil, or in fine sand that may shift, the tee shall be anchored to the branch by a cable of the size indicated in the table. A collar shall be built aroundthe bell three joints back from the junction, and a sling around the tee. The cable will be fastened to eyes that will permit fastening to a turnbuckle of wrought iron. For hydrant connections on such lines, the collar built around the hydrant will be connected with cable to the collar or sling on the tee. The table shows sizes of cables, collars, and turnbuckles.

20. SETTING HYDRANTS AND VALVES: (a) Hydrants and valves will be placed where ordered by the Engineer. Hydrants are to be set at the unit price bid, but the price bid for pipe laying is to include the placing of all valves and cast iron valve boxes.

(b) Hydrants, valves and boxes must be plumb. The valve boxes shall be placed directly over the valves, the top of the box being brought to the surface of the street or alley. After being put in place, earth shall be filled in the trench and thoroughly tamped around the box. The trench shall be filled in this manner for a distance of four feet on each side of the box.

(c) Hydrants are to set at such an elevation that the connecting pipe and the distributing mains will have approximately the same depth of cover. Each hydrant shall be placed upon a slab of stone or concrete not less than three (3) inches thick and fifteen (15) inches square. Around the base of each hydrant shall be placed not less than seven (7) cubic feet of broken stone or gravel, so hydrants will completely drain when closed.

(d) Before placing any hydrant or valve, care shall be used to see that all foreign material is removed from within the body or barrel. The stuffing boxes should be tightened and the hydrant and valve opened and closed to see that all parts are in a first-class working condition.

(e) Attention is directed to paragraph 19 of these specifications, covering the blocking of hydrants and hydrant connection tees in the main.

21. VALVE BOXES: Concrete or brick valve boxes for large valves installed in the horizontal plane, shall be built where directed by the Engineer, in accordance with detailed plans and specifications prepared therefor. Payment for such boxes shall be either on an agreed price, or as "Extra Work".

22. FIELD TESTS: (a) When a section of pipe line between two gate valves has been laid, and prior to backfilling, it shall be submitted to a hydrostatic test of one hundred fifty (150) pounds per square inch. While under this pressure, pipe, specials and joints shall be examined for leakage; defective joints shall be recalked or replaced and defective pipe or special castings shall be removed and replaced.

(b) In making preparations to test pipe lines, the isolated section shall be filled while all hydrants are open, to free entrained air. Hydrants shall then be closed and pressure carried at one hundred (100) pounds for ten minutes prior to applying the test pressure of one hundred fifty (150) pounds.

(c) The pressure pump used for testing may be connected to one hose outlet of a hydrant, and the pressure gauge to the other.

(d) The Contractor will furnish all testing equipment excepting test gauges, which will be furnished by the Company.

23. MEASUREMENTS OF AND PAYMENT FOR WORK: The measurement of different sizes of pipe lines, on which payment will be made at the unit prices named in the proposal,will include all pipe lines, special castings and valves, no other payment being made for any of the work in connection therewith for excavating, placing jointing and backfilling. Hydrant connections will be measured from the hub of the hydrant to the center line of the main. Excepting in the case of items classified as extra work, the unit prices named in the proposal are to cover all work to be executed under this contract.

Longview, Washington

Instructions to Bidders,

Preliminary Estimate of Quantities,

Proposal, Specifications & Contract

for

Sanitary Sewers

1923.

Longview, Washington.

INSTRUCTIONS TO BIDDERS ON SANITARY SEWERS

(1) Sealed bids will be received by The Long-Bell Lumber Company, Longview, Washington, up to __________ o'clock ______ M., ______________________________ 1923, and then opened, for furnishing all labor, equipment, tools, and such materials as are not specified to be furnished by The Long-Bell Lumber Company, and constructing sanitary sewers in Longview Townshite, in accordance with plans, profiles and specifications on file in the office of the Chief Engineer of the Company.

(2) Plans may be examined and the forms on which all bids shall be made, may be obtained at the office of the Chief Engineer. Bidders may obtain plans for their own use by making a deposit of ______________________; ______________ __________ of which amount will be refunded on the return of the plans; __________ ________________________ being retained to cover cost of printing.

(3) When filed, bids shall be enclosed in a sealed envelope, addressed to The Long-Bell Lumber Company, marked on the outside with the name and address of the bidder, and shall be accompanied by a certified check on a Kelso, Washington, bank, or by a Cashier's check on any bank, in an amount approximating five (5) per cent of the amount of the bid, provided that no check for less than $1,000.00 or more than $15,000.00 shall be filed. All checks shall be left in the hands of the Company as a guarantee that the bidder will, if the contract is tendered him, enter into contract and furnish the required bond within the time specified in the annexed proposal. Checks of unsuccessful bidders will be returned when their bids are rejected. Checks of successful bidders will be returned when the contracts have been signed, and the required bond furnished and approved by the Company's attorneys.

(4) Bidders shall fill in all blanks on the bidding forms; when firms bid, names of the individual members shall be given in full, and the firm name added. The place of residence of each bidder shall be given. Each bidder shall state in his proposal the date on which he proposes to complete the work if the contract is awarded him. None of the instructions to bidders, bidding form, estimate of quantities, specifications or contract shall be detached from the bound copy before filing with the Company. All bids will be compared on the basis of the Engineer's preliminary schedule of quantities.

(5) The successful bidder, before starting construction, will be required to give bond in the full amount of the contract, with a surety company authorized to do business in the State of Washington, and acceptable to the Company as surety.

(6) All bidders shall examine for themselves the location of the proposed work, and the nature of the excavation to be made.

(7) Payment for the improvement will be made in cash; the Engineer will prepare monthly estimates on which eighty-five (85) per cent will be paid on or about the first of each month, fifteen per cent being retained until the completion, final inspection and acceptance by the Company of the work contracted.

(8) The Company reserves the right to reject any or all bids, or waive defects in bids.

Longview, Washington.

ENGINEER'S PRELIMINARY SCHEDULE OF QUANTITIES,

FOR SANITARY SEWER CONSTRUCTION.

PROPOSAL FOR SANITARY SEWER CONSTRUCTION

TO THE LONG-BELL LUMBER COMPANY,
LONGVIEW, WASHINGTON.

GENTLEMEN: Having examined the plans, specifications and contract, and being fully informed relative to the location, character and extent of the work to be performed in connection with the construction of sanitary sewers in Longview Townsite, the undersigned hereby propose to furnish all labor, equipment, tools and such materials as are not specified to be furnished by the Company, and construct complete sanitary sewers, in accordance with the detailed plans, specifications and contract on file in the office of the Chief Engineer, at the following prices, towit:

ITEMS	PRICE IN WORDS	PRICE IN FIGURES
For furnishing all labor, equipment, tools and materials necessary for excavating and backfilling for sewers, wasting excess material, and including all pumping, bracing, sheeting, timbering, and protection of all structures along the lines of the work, either above or below ground, at the following prices, viz:		
For all classes of excavation except rock, per cubic yard,		($)
For rock excavation, per cubic yard,		($)
For furnishing all labor, equipment, and tools necessary to transport pipe, specials and other construction materials from stock piles, warehouses, or at other specified points of delivery by The Long-Bell Lumber Company, to the site of the work, and constructing the improvement in place as specified, at the following prices, viz:-		
For precast concrete sewer pipe and specials laid with jute and cement joints,		
4" precast sewer, per linear foot,		($)
6" " " " " " ,		($)
8" " " " " " ,		($)
10" " " " " " ,		($)
12" " " " " " ,		($)
15" " " " " " ,		($)
18" " " " " " ,		($)
21" " " " " " ,		($)
24" " " " " " ,		($)

ITEMS	PRICE IN WORDS	PRICE IN FIGURES
27" precast sewer, per linear foot,	______	($______)
30" " " " " " ,	______	($______)
36" " " " " " ,	______	($______)

For joints made of______jointing compound, furnished by the Company, in addition to linear foot price for corresponding size of pipe with cement joints, for

4" precast sewer, per joint,	______	($______)
6" " " " " ,	______	($______)
8" " " " v " ,	______	($______)
10" " " " " ,	______	($______)
12" " " " " ,	______	($______)
15" " " " " ,	______	($______)
18" " " " " ,	______	($______)
21" " " " " ,	______	($______)
24" " " " " ,	______	($______)
27" " " " " ,	______	($______)
30" " " " " ,	______	($______)
36" " " " " ,	______	($______)

For brick manholes,______feet from top of cover to flow line, each,______($______)

Addition or deduction for each six inch variation from______foot dimension,______($______)

For concrete manholes,______feet from top of cover to flow line, each,______($______)

Addition or deduction for each six inch variation from______foot dimension,______($______)

For brick flush tanks______feet from top of cover to flow line, complete,______($______)

Addition or deduction, for each six inch variation from above______ dimension,______($______)

For concrete flush tanks______feet from top of cover to flow line, complete,______($______)

Addition or deduction, for each six inch variation from above______dimension,______($______)

For transporting materials furnished by Company, trenching, tapping water main, placing goose necks 3/4" galvanized pipe, stop cocks, connecting to flush tanks, and backfilling, per lin. ft. of line,______($______)

The undersigned hereby agrees to furnish the required bond and to enter into contract within ten days from the date of your acceptance of this proposal to finish and complete the work covered by this bid on or before_______________
_______________________.

If this proposal is accepted, and should___________for any reason fail to furnish the required bond and sign the contracts within ten days as above stipulated, the check which has been this day deposited with The Long-Bell Lumber Company shall, at the option of the City be absolutely forfeited to The Long-Bell Lumber Company, but otherwise the check shall be returned to the undersigned on the signing of the contract and approval by the Company of the contract bond.

DATED AT LONGVIEW, WASHINGTON, this_____day of_________________________________
A. D. 1923.

Names.	Addresses.
______________________	______________________
______________________	______________________
______________________	______________________

Longview, Washington.

SPECIFICATIONS AND CONTRACT FOR THE CONSTRUCTION OF

SANITARY SEWERS.

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1. These specifications, together with the attached "Instructions to Bidders", "Preliminary Schedule of Quantities", "Proposal", and "Contract", together with the plans and profiles for this improvement now on file in the office of the Chief Engineer of The Long-Bell Lumber Company, such special specifications and plans as may be necessary from time to time during the progress of the work, and the laws of the State of Washington controlling and limiting contract operations of this nature, all taken as a whole, shall constitute the contract under which the specified improvements shall be executed.

2. DEFINITION OF TERMS: Whenever the term "Company" appears in the "Instructions to Bidders", "Schedule of Quantities," "Proposal form", "Specifications", or "Contract", or on the plans, it shall be understood to mean The Long-Bell Lumber Company, the party of the first part as incorporated and operating under the laws of the State of Missouri and admitted to operate in the State of Washington. The term "Engineer" shall mean the Chief Engineer of the Long-Bell Lumber Company, or his duly authorized agents. The term "Contractor" shall mean the second party to the contract.

3. EXAMINATION OF GROUND: Bidders must examine and judge for themselves the location of the proposed work and the nature of the excavation to be made. The plans, profiles and other drawings for the work show conditions as they are supposed and believed to exist, but it is not intended that the conditions as shown by the plans and profiles constitute a representation of the Company, or of its officials or agents that such conditions actually exist. Neither shall the Company nor any of its officers or agents be liable for loss sustained by the Contractor as the result of variance between the conditions as shown by the plans and profiles and the actual conditions revealed during the progress of the work.

4. EXPLANATORY NOTES OR FIGURES: Explanatory notes or figures on plans shall take precedent over scaling, and any discrepancy or misunderstanding concerning plans or specifications shall be decided by the Engineer, whose decision shall be taken as final and conclusive. Prior to submitting a proposal on work the Contractor shall take up with the Engineer items not clearly understood, or items which may later form the basis of a misunderstanding. The work herein described is to be completed in every detail notwithstanding that every item involved is not specifically mentioned.

5. MATERIALS FURNISHED BY COMPANY: It is the intent of the specifications that the Contractor shall furnish for the prices bid, all labor, equipment, tools, and machinery required for the complete performance of this contract, in full accordance with the plans and specifications. The Company will furnish all sewer pipe, wye branches, specials, manhole and flushtank rings and covers, syphons, steps, goose necks, stock cocks, flushtank meters, wrought iron pipe, brick, cement, sand, stone, gravel, and all other materials necessary, except-

ing lumber, nails, jacks, or special materials or equipment used for timbering, sheeting, bracing, and pumping water from the sewer excavation. The Contractor shall transport from warehouses, yards, wharves, or other specific locations named at the time of entering into this contract, to the site of the work, all materials furnished by the Company, without charge other than is included in the unit prices bid.

6. CEMENT: (a) Cement shall be first-class Portland Cement, and shall meet the current specifications of the American Society for Testing Materials. It shall be well packed and the brand and name of the manufacturer plainly marked on the barrel or sack. It shall be fresh and properly seasoned. All cement furnished the Contractor by the Company will be subject to inspection at any time up to its use in the work, and if found to be of improper quality will be branded and must be immediately removed from the work. The Contractor shall submit the cement for inspection, giving sufficient time for testing before any part of it is used in the work.

(b) The Contractor shall at all times keep in store sufficient quantities of cement to allow time for tests without delay to the work of construction. The cement must be stored in a tight building and all sacks must be raised from the ground.

7. SAND: Sand shall consist of "Sharp" grains from hard, tough, durable rocks, and shall be free from clay, loam or organic matter, not more than five (5) per cent of it shall pass a #200 sieve.

8. STONE: (a) The stone for concrete shall be of best quality of hard trap-rock or granite boulders. It shall be free from mud, dirt, dust, loam or other objectionable material. When the Engineer shall order, it shall be screened to remove dust.

(b) All broken stone used in reinforced concrete work shall pass a one (1) inch ring with its greatest dimension. Broken stone used in foundations and unreinforced walls shall pass a 2-1/2 inch ring with its greatest dimension, and if necessary, stone shall be screened to conform to these sizes.

9. BRICK: All brick used in manholes shall be of uniform texture, hard burned entirely through, free from lime or other impurities that will affect them in air or water.

10. PROPORTIONING CONCRETE BY PARTS: In proportioning concrete by parts, the standard bag of cement weighing not less than ninety-four (94) pounds net, shall be taken as one cubic foot; sand and stone shall be measured accurately from a box prepared for that purpose, to determine the proper point to which wheelbarrows shall be filled, and the depth of filling shall be indicated by marks on the inside of the barrows.

11. CEMENT MORTAR: (a) All cement mortar for brick work shall be made of one (1) part of cement and three (3) of sand. Limewater may be used to temper the mortar for brick work, but the lime shall not replace cement and the amount of lime shall not exceed fifteen per cent, by weight, of the amount of the cement.

(b) Cement mortar for pipe joints shall be made of one (1) part cement to one (1) part sand.

(c) In mixing mortar, cement and sand shall be thoroughly mixed dry and such quantity of water added as is necessary to form a paste of proper consistency. All mortar shall be fresh for the work at hand; mortar that has begun to set will be thrown away. All mixtures shall be made by actual measurements.

12. CONCRETE: (a) The concrete used in reinforced concrete shall be made of one part cement, two parts of sand, and four parts of broken stone. The cement content per cubic yard of finished concrete shall not be less than 1.5 barrels for 1-2-4 concrete or 1.15 barrels for 1-3-5 concrete.

(b) All concrete shall be machine mixed except in the case of concrete for manholes or other isolated small structures where hand mixing will be allowed. At all times the methods followed in machine and hand mixing, and the type of equipment used, shall be subject to the approval of the Engineers. Concrete shall be used immediately after mixing and shall be thoroughly mixed of such a consistency that it flows well in forms, but shall not be so wet that aggregate will separate out. On approval of the Engineer, bed gravel may be used for concrete work. In the event that gravel is used instead of stone, the Engineer shall determine the proper proportions of cement and sand to be used, after the gravel is delivered to the site of the work. The right is reserved to change the proportions of rock or sand at any time to secure a tight concrete.

(c) No concrete shall be mixed or placed in the work when the temperature is below 32° Fahr., and the Contractor shall use such methods to protect finished concrete from freezing, before it has thoroughly set, as may be necessary.

13. REINFORCING STEEL: Reinforcing steel shall fulfill the latest specifications of the American Society for Testing Materials for what are known as round deformed rail steel concrete reinforcing bars or billet steel concrete reinforcing bars.

14. FORMS: (a) All forms for concrete shall be constructed by experienced carpenters, and shall be built and braced in such a manner that they will not go out of line when concrete is deposited in them.

(b) The forms for all walls should preferably be such as to allow continuous pouring the full height of the wall. Especial care shall be used to have tight forms for all of the walls.

(c) Forms shall not be removed until the concrete has set sufficiently to carry any load which may be thrown on it by such removal. The lengths of time required shall be subject to the approval of the Engineers.

15. CEMENT-CONCRETE SEWER PIPE: (a) The sewers are to be built of cement-concrete sewer pipe and specials conforming in all details and subject to all tests and requirements of the Standard Specificatinns for Cement-Concrete Sewer Pipe as adopted in Amended Form 1920 by the American Society for Testing Materials.

(b) Pipe and specials shall be inspected by the Engineers after delivery at the point where it is to be used, and all rejected pipe shall be clearly marked with paint or with other marking material that shall be approved by the Engineer. Any subsequent inspection deemed necessary by the Engineer shall be made by him after the pipe has been placed in the work.

16. PROTECTION OF PROPERTY; (a) The Contractor shall at his own expense shore up, protect and insure from injury, all buildings, walls, fences, pavements, curbs, trees, sewers, water mains, service pipes, lamp posts, drains, and all other structures which may be met with in carrying out the work. In case any of those are removed during the work, they shall be replaced by the Contractor at his own expense in as good condition as they were before being removed, and in case of his refusal to make such repairs, they shall be made by the parties having control of the same, and the expense shall be deducted by the Company from the amount which may be or become due the Contractor.

(b) The Contractor shall erect suitable barriers around all excavation and materials piled in the streets, alleys, or highways, to prevent accidents to pedestrians, animals or vehicles, and shall place and maintain during the night, sufficient red lights on or near all work to properly warn pedestrians and persons in vehicles of danger.

(c) The Contractor shall give notice in writing at least twenty-four hours before breaking ground, to all persons (Superintendents, Inspectors and Agents) in charge of the streets, alleys, or highways, water mains, railroads or other property, that may be affected by his operations; and the Contractor shall not cause any hindrance to or interference with any such person, persons, company or companies in protecting their property, but the said Contractor shall permit the said person, or persons, company or companies to take such measures as they deem necessary for the purpose aforesaid.

(d) All railroad tracks and track structures crossing the line of the sewer shall be supported by the Contractor during the construction under or near them; the work shall be so prosecuted as to not interrupt the use of the tracks or endanger the traffic on them, and such tracks and track structures shall be restored full to their original condition.

(e) Should any water mains or conduits be encountered that are on the same level as the sewer, or that require elevating or lowering, the Contractor shall raise or lower the pipe under the direction and to the satisfaction of the Engineer, and shall be paid therefor as provided under "Extra Work" in the Contract.

(f) The Contractor shall be required to observe all the City ordinances and State Laws in relation to obstructing streets, alleys and highways, keeping open passageways and protecting the same where exposed, and generally to obey all ordinances, rules and regulations controlling or limiting those engaged on the work.

(g) At the suspension of any work the trenches shall be filled and streets or roadways left clean and free for travel.

17. LOCATION AND GRADE OF SEWERS: (a1) The sewers shall be located on the lines shown on the plans of the work, and will be staked out by the Engineer, in advance

of the Contractor's requirements. The line for trenches will be indicated by stakes set at one side of the trench. The bottom of the inside of the sewer is the grade line shown on the plans, and for construction purposes the grade will be given a line parallel to the sewer grade and supported above the ground surface on straight edges spaced twenty five or fifty feet apart as required, or by such other method as the Engineer may determine is necessary or desirable.

18. EXCAVATION: (a) There will be but one classified material, namely rock, which is described under "Rock Excavation." All other material will be excavated at the price bid per cubic yard for excavating and backfilling. The Contractor shall start the work of excavating at such points on the line of the sewer as the Engineer may direct, and shallprogress from point to point, or from the outlet or toward the outlet at the option of the Engineer.

(b) Under ordinary conditions excavation shall be by open cut from the surface, tunneling will not be allowed except by permission from the Engineer. The width of trench is regarded as essential, as sufficient room must be given to properly joint the pipe and work freely around it, and except as provided for under "Rock" this width shall be 12 inches wider than the outside diameter of the pipe except where in the Engineer's opinion, timbering is necessary. The material excavated shall be deposited on the sides of the trenches, beyond the reach of slides, in such a manner that other contractors and the public will be inconvenienced as little as possible.

(c) The Contractor shall provide for all water courses and drains disturbed during the progress of the work, and replace them in as good condition as he found them, purchasing new material to replace all that is broken by him or his men during the work.

(d) The Contractor shall not open up more trench in advance of pipe laying than is necessary to expedite the work, and 400 feet will be the maximum open trench allowed.

(e) In laying pipe sewers the trench ahead of the pipe shall be excavated to within six (6) inches above grade. In cases where wet or caving trench makes it necessary to lay but one or two joints of pipe at a time, the pipe layer, at the direction of the Engineer, will be allowed to excavate a greater depth than six (6) inches, and backfill over the pipe.

(f) Failure to properly timber, brace of sheet trenches shall be at the risk of the Contractor. No allowance will be made for materials used in timbering, bracing or sheeting, unless the Engineer considers it necessary to leave such lumber in the trench. In such cases the Contractor will be paid the price per thousand feet board measure, named in his proposal.

(g) Excavation for manholes, flush tanks, and other accessories, shall be of such size that the outside of such structures may be plastered where required by the specifications or plans. Excavation for concrete structures may serve as the outside form, if in the opinion of the Engineer, first-class work can be secured in this manner.

(h) Should trench be excavated to a greater depth than that given by the Engineer, the Contractor will refill to grade at his own expense with well tamped material, designated by the Engineer, notwithstanding that it may be necessary to bring such material from other localities.

(i) Whenever in the opinion of the Engineer, material in the trench bottom is not suitable for sewer foundations, the Engineer shall order and the Contractor shall excavate below grade and refill with such material as the Engineer may direct. If wooden inverts, saddle piles, stringers and saddles, timber, cement or masonry foundations are made necessary by quicksand or other treacherous ground, they shall be placed as directed by the Engineer. Payment for excavation and refilling made necessary by unsuitable trench bottom, shall be made on the basis of the unit price named in the proposal, for excavating and backfilling. Wooden inverts, saddle piles and all other types of foundation adopted, shall be paid for at a price agreed upon by the Contractor and Engineer prior to the time the work is done. In the event a price is not so agreed upon, materials and labor shall be furnished and performed in accordance with those provisions of the contract covering "Extra Work."

(j) The calculation of cubic yards of excavation will be based on vertical trench walls, with trench widths twelve (12) inches wider than the outside diameter of the pipe, excepting in the case of Rock excavation, and in cases where the Engineer has ordered greater widths because of timbering, bracing or sheeting.

19. ROCK: (a) All shale or loose rock which can be removed by a pick or bar, shall be classed as earth excavation; all shale or loose rock requiring blasting for its removal shall be classed as rock. The Engineer shall in all cases decide whether or not blasting is necessary. The fact that the Contractor may find that it is expedient to blast material, which, in the opinion of the Engineer, can be removed without blasting, shall in no manner change or modify this classification or entitle the Contractor to any pay for material so moved as rock. All loose stone or boulders under five (5) cubic feet in volume will be classed as earth; and all boulders, ledge or stratified rock having (5) five cubic feet or over in volume, shall be paid for per cubic yard as rock. When rock occurs in layers separated by shale or clay, such separating layers will be classified as rock except where they are five-tenths of a foot or more in thickness.

(b) Where rock and shale are encountered and blasting is necessary, suitable plank covering or brush mattresses shall be provided to prevent injury to property or life.

(c) Where rock occurs at the bottom of trenches, it shall be removed to such a depth as will permit at least three inches of sand or loam to be placed below the pipe for a bed. Such bed shall be placed by the Contractor at his own expense. The width of sewer trench in rock excavation shall not be less than 12 inches greater than the outside diameter of the barrel of the pipe being laid, and in all cases where rock excavation makes necessary a greater quantity of earth excavation than in trenches where no rock is encountered, the Engineer and Contractor shall agree prior to backfilling the trench on the quantity of excavation.

(d) The measurement of rock shall be made by the Engineer by taking levels on top of the rock surface before it is removed from the trench and measuring the actual cross-section of rock trench. Rock will be paid for by the cubic yard at the price named in the proposal. Rock will not be paid for outside a cross-section six (6) inches below the bottom of the sewer, twelve (12) inches wider at the bottom than the external diameter of sewer barrel, and with side slopes of three (3) inches in five (5) feet. The limiting cross-section will be used in figuring rock excavated when the nature of the rock encountered makes it necessary to blast an irregular ditch approximating the limiting cross-section in area. If the Contractor finds it unnecessary to blast as much rock as allowed by the limiting cross-section, payment will be made only for the amount actually excavated.

20. PIPE LAYING: (a) After pipe laying is commenced each day it shall be continued until at least thirty (30) feet is laid before backfilling is commenced, and at all times the pipe shall be so laid that lines, grades and joints may be checked for from thirty to fifty feet at least over finished pipe. The work may be closed in each night, and in wet or caving trenches, the Engineer may give special permission to fill closer to the last pipe laid than herein specified.

(b) No sewer shall be laid or other work in connection with this improvement be performed except in the presence of the Engineer or his Inspectors. The Engineer shall have the power to cause the removal of sewer laid or other work constructed, during his absence from the work, but it shall be the duty of the Engineer or his Inspector to be present at any hour of the day or night whenever previously notified by the Contractor that he will lay sewer.

(c) No sewer requiring mortar joints, or concrete construction, cast in place, shall be laid when the temperature is below 32° F., unless special means for the protection of the work from frost or freezing is provided which meet the approval of the Engineer. Sewer trenches must be kept free from water during the progress of the work as no pipe shall be laid in water. When brought to grade, each pipe section shall be supported by the barrel of the pipe, and not on blocking or wedging under the pipe or bell. Whenever the nature of the ground will admit of it, the bottom of the excavation is to have the shape and dimension of the outside and of the lower half of the sewer; in the case of pipe sewers the bottom of the trench underneath the socket shall be hollowed sufficiently to admit the socket and permit the pipe layer to place jute in the joint and cement it from the outside.

(d) All pipe when jointed in the trench shall form a true and smooth line of sewer. Perimssible defects in pipe shall be placed on top. In no case shall pipes be trimmed. Pipe which does not fit truly will be rejected. Especial care shall be taken to lay the pipe to the exact grade and line.

(e) In the case of bell and spigot pipe a gasket of jute or other material approved by the Engineer, shall be calked without the use of a hammer, into the joint around the entire circumference of the pipe in one continuous piece, in such a manner as to prevent the entrance of cement to the inside of the pipe, and enough shall be put in to bring the flow line of adjoining pipes to a true surface and line with each other. No joints shall be cemented until the gasket of the next joint in advance has been completed. In wet trenches the Engineer may require the jute to be dipped in neat cement before being placed in the joint. A mortar of one part Portland cement and one part sand shall be firmly pressed with the hands, into the space between the socket and spigot, so as to entirely fill the space for the whole circumference of the pipe, and a beveled joint made at the end of the socket. Special care must be taken to make perfect joints at the bottom of the pipe, but no cement shall be placed in the bell of the pipe until the entering pipe is in position and the gasket of the next joint is made. In wet trenches the joints shall be protected with clay puddle, or with muslin or canvas bands if necessary to prevent the cement from coming loose or dropping off.

(f) At the option of the Engineer, patented or special types of joints may be used. If such joints are selected in advance by the time bids are received, the Contractor may make a unit price in the proposal for laying sewer with such joints furnished by the Company. If the jointing compound to be used is selected after contracts are awarded the increase or deduction from the bid prices for making jute and cement joints, shall be agreed upon by the Contractor and Engineer. Each joint must be examined to see that no cement or gaskets project into the pipe. If any be found, it must be carefully and thoroughly removed prior to backfilling over the pipe, or if undiscovered until later, before final acceptance of the work it shall be removed by whatever means are found necessary.

(g) Should the Engineer be of the opinion that any pipe has not been properly cemented, he may order the removal of that pipe for inspection, and if it is found to be deficient in cement he may order as many more removed as may be necessary to satisfy him that the remainder are in good condition.

(h) The excavation made for the socket must be carefully filled with sand or fine earth or clay to support the cement and joints in position. The whole length of the pipe except the socket must be firmly bedded on the graded portion of the trench. This must be done by scraping or filling earth under the body of the pipe and not by blocking or wedging under the pipe or socket.

(i) In calculating the length of sewer for which payment will be made at the unit price bid per foot; the internal diameter of manholes and flushtanks will be deducted except in cases where the sewer has been laid through manholes or flushtanks.

21. SEWERS TO BE KEPT CLEAN & FREE FROM WATER: (a) All sewers must be kept thoroughly clean and no water will be allowed to run through them during their construction until the joints have thoroughly set, and then only with permission of the Engineer. When completed, the joints of the pipe sewers shall exclude all ground water.

(b) When the trench is left at night, or the pipe laying stopped for some cause, the ends of the pipe shall be closed by using a circular end board, closely fitting the socket end of the last pipe, the end board shall have a large number of small holes bored near the center to prevent the trench filling with water, and to keep out sand and earth from the sewer; in no case shall the end board be inserted and water allowed to enter the sewer until the Engineer is satisfied that the joints in position are sufficiently set so as not to be injured by water. This clause shall not prevent the Engineer from ordering, but upon the contrary he may order the end of the sewer closed absolutely tight whenever he determines that, in order to secure good results, the water shall be excluded from the sewer. This right shall not be abridged or limited by any clause herein to the contrary. When quicksand or other treacherous ground is encountered, the work shall be carried on by day and night, should the Engineer so require, but at the Contractor's expense.

(c) Any sand, gravel, quicksand or mud getting into the pipes, shall be removed by the Contractor at his own expense.

22. BACKFILLING: (a) In backfilling, the sewer shall not be disturbed by throwing the earth upon it from the top of the trench, or by walking on, or by the side of the sewer, or by pulling the sheeting or in any other manner. After a small portion of the sewer has been covered six (6) inches deep, a man will stand on the filling and shovel earth ahead to cover the pipe.

(b) In backfilling, the earth shall be kept at the same height on both sides of the trench, and shall be rammed in layers not more than six (6) inches thick up to one (1) foot above the top of the pile, a heavy wooden or iron rammer being used for this purpose. The remainder of the trench may be filled by scrapers, and settled with water. No top dressing shall be done until the water has settled away.

(c) In case the excavation fails to furnish suitable material for tamping and filling around the sewer and over it, the Contractor shall provide such material as will, in the opinion of the Engineer, be suitable, bringing the same from another locality or part of the work if necessary, without extra charge.

(d) No stones shall be placed in the trench around or near the sewer. Where rock is encountered in the trench, in backfilling earth filling shall be carried up to at least two (2) feet from the top of the sewer and the stone mixed with the remainder of the filling; excepting that no stone shall be used in the upper eight inches of the trench.

(e) All backfilling under curbs, cross walks, or other surface structures shall be replaced and rammed to the satisfaction of the Engineer, the number of tampers being equal to the number of fillers.

(f) All streets, alleys and highways must be passable to traffic within three days after pipe is laid. All streets, alleys and highways must be cleaned up and put in orderly condition before the work contained in that portion is included in any estimate. All unused pipe and other materials must be removed before the street shall be considered clean.

(g) When sewers are built in or across streets, alleys or highways, which have been macadamized, or graveled, the Contractor must save the gravel or stone and refill the upper part of the trench with such material to the thickness of the original roadway, supplying at his own expense, all deficiencies with freshnew stone or gravel to bring the streets, alleys or highways to their original grade.

(h) The Contractor is required not to sell, remove or permit to be removed from the line of the work before the trenches shall have been refilled, any sand, gravel, rock or earth excavated therefrom which may be suitable and required for refilling; and all material taken from trenches and not required for refilling shall be removed at the expense of and by the Contractor and put in such place or places, not exceeding one-half mile haul in distance, as the Engineer may direct. All rock and other material excavated and not used in the work is to be and remain the property of the Company and is to be piled as directed by the Engineer.

23. MANHOLES: (a) Manholes shall be constructed in accordance with the detailed drawings. They shall be built of brick or concrete. Brick manholes shall be built of hard well burned brick, laid in cement mortar and plastered outside with cement mortar, not less than one-half (1/2) inch in thickness. At the option of the contractor, joints on the inside of manholes may be struck smooth, or the manholes may be plastered not less than one fourth (1/4") inch thick with cement mortar, from the bottom of wall to the bottom of corbel. When the depth of trench will not permit sufficient head room in manholes for at least eighteen (18) inches of vertical wall, the sides shall be carried up vertically and the top made of reinforced concrete slab construction as shown on the plans. All manhole covers shall be provided with dust pans of kind and design approved by the Engineer.

(b) Concrete foundations for manholes shall not be less than eight (8) inches in thickness below the bottom of pipe sewers. When practicable the main sewer shall be carried through manholes by split pipe. Concrete filling between the sewer invert and walls of manholes shall be flush with the top edges of the invert and shall slope up from the invert at the rate of two (2) inches to a foot. Concrete used in the foundation of either brick or concrete manholes shall be one, two, four concrete.

(c) When manholes are built of concrete they shall conform to detail plans shown on sheet of Standards. A concrete manhole whose depth from base of manhole ring to invert is four feet or less shall be built as a shallow manhole in accordance with detail plans.

(d) Where it is not practicable from the grade of incoming sewers, to use split pipe through manholes, the sewer invert shall be made of concrete deposited between forms, or of brick on edge, laid up in cement mortar. The shape of the invert shall exactly conform to the lower half of the pipe it connects. Side branches shall be connected with as full a curve as possible. Inverts whether of concrete or brick shall be plastered with cement mortar and left smooth and clean.

(e) In special cases where water is found, the Engineer may direct the main sewer to be laid continuously through the manhole location, the latter to be built afterward. In such cases, the foundation of brick or concrete shall be laid and carried up to a height somewhat above the lower half of the pipe. After the manholes are carried up, the upper half of the pipe may be cut out and bottom finished.

(f) Drop manholes and other special forms shall be built in accordance with the detail plans and all specials, connections, drops and all other sewer pipe appurtenances built into walls are included in the prices paid for manholes.

24. FLUSH TANKS: (a) Flush tanks shall be constructed at the locations designated on the sewer map and in accordance with the detailed plans. The excavation shall be of sufficient width to allow plastering when called for by the plans, and for thoroughly tamping backfill around the walls. The foundations and floor of tanks shall be made of concrete. The walls shall be of either hard burned brick carefully laid in cement mortar, or of concrete. Brick walls shall be plastered outside from bottom to top and inside to a point above the overflow pipe, with a one-half (1/2) inch layer of cement mortar, composed of two parts sand one one part Portland Cement. Before this has thoroughly dried the inside walls and bottom shall be brushed with as many coats of cement grout as may be necessary to make the tank water-tight. Plastering, but not grouting, will be omitted on concrete tanks. Each tank shall be fitted with iron manhole steps spaced sixteen (16) inches apart vertically, and cast iron ring, cover and dust pan of the same weight and design used for manholes. Shallow flush tanks shall be built either of brick or concrete in accordance with the detailed plans, when the required capacity cannot be gotten with ordinary construction on account of head room.

(b) Each tank shall contain an automatic flush tank syphon of a type approved by the Engineer. The syphon shall be guaranteed not to waste water by weeping or dribbling and shall discharge the tank rapidly whenever the flushing level is reached. The trap and bell of the syphon shall be of a cast iron of the type and size specified by the Engineer for given locations in the system. The syphon shall be set at one side of the sewer line, and a special removable elbow or other means shall be provided to permit easy access to the sewer for cleaning with sewer rods.

(c) The feed pipe shall be fitted with a standard stop-cock and water regulator. The regulators shall be made of non-corrosive metal and each regulator shall be guaranteed to fill the tank to the flushing level and not more often than once in twenty-four hours, when supplied with water under the normal head for that location. The regulators shall be provided with a cock for filling the flush tank independently from the calibrated orifice and with a stop-cock for shutting off the flow of water.

(d) The connections from the City water mains to the flush tanks will be made of 3/4" W.S. full weight galvanized pipe, with all joints carefully leaded before the couplings are screwed tight. The connection at the main is to be made with a standard lead goose-neck and corporation cock.

(e) After tanks have been constructed, they shall be inspected and tested for water tightness by the Contractor for a period of twenty-four hours to the satisfaction of the Engineer.

25. REPAIRING AND REPAVING STREETS: (a) If at any time during the period of one year from the date of final completion and acceptance of the sewer, the roadway on the line of the sewer shall require regrading, repaving, or regraveling by reason of settlement of the trenches, the Company shall notify the Contractor to make the required repairs, and if the Contractor shall neglect, for a period of ten days, to make such repairs to the satisfaction of the Company, then the

Company shall have the right to cause the repairs to be made and to charge the expense thereof against the bond given the Company by the Contractor for that purpose.

(b) All material such as plank, paving blocks, brick, broken stone, cross walk or curbing that may be lost, damaged or broken by the Contractor during the progress of the work, shall be replaced by him at his own expense, unless such material shall be decided by theEngineer at the time of the removal, to be in such condition that it is impossible to remove and replace it by reason of its condition, in which case the Contractor shall be allowed the actual cost of such new material as he may be ordered to use to replace such decayed material, but no allowance shall be made for hauling or putting such new material in place. No compensation other than the price bid for the sewer will be allowed in streets, alleys and highways that are graveled.

CONTRACT

Contract as worked out by Mr. L. A. Perry and E. B. Black in January suggested as type of contract to accompany these specifications.

Longview, Washington

Precipitation in inches, by months from 1900 to 1922 inclusive,

for

Astoria
Castle Rock
Kalama
Olympia
Portland
Rainier
Seattle
Vancouver

Longview, Washington

Precipitation in inches, by months, from 1900 to 1922 inclusive, at the Cities listed.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1900													
Astoria	10.35	10.73	8.68	3.45	5.68	6.60	0.95	1.87	2.78	8.50	9.13	16.25	84.97
Olympia	5.96	5.37	6.89	1.84	5.34	3.75	0.28	0.68	1.86	8.26	6.11	10.03	56.37
Portland	4.58	3.36	4.63	1.30	3.90	1.76	0.34	2.04	1.93	3.87	4.50	6.01	38.22
Rainier													
Seattle	3.04	4.35	4.45	1.55	3.73	2.51	0.66	0.30	0.72	4.16	3.80	7.21	36.48
Vancouver	4.00	3.90	4.55	2.13	4.40	2.66	0.82	0.32	1.96	4.25	4.34	7.10	40.43
1901													
Astoria	10.84	9.49	8.59	7.84	3.23	3.14	1.12	0.06	4.71	4.38	14.56	9.91	77.87
Olympia	8.57	7.16	4.25	7.24	3.06	1.04	0.49	0.12	2.69	2.94	11.52	6.01	55.09
Portland	7.80	6.52	4.12	4.05	2.41	1.39	0.12	0.17	3.57	0.75	6.14	4.01	41.05
Rainier													
Seattle	4.26	4.26	1.62	3.86	1.44	1.90	0.35	0.13	2.30	1.44	6.17	2.45	30.18
Vancouver	6.66	6.70	4.71	3.36	2.29	1.89	0.18	0.18	3.07	1.10	6.74	3.68	40.56
1902													
Astoria	7.23	16.33	10.41	5.34	4.09	2.80	2.89	0.45	2.28	3.50	15.87	15.29	86.48
Olympia	7.15	11.68	6.78	5.17	2.43	0.74	1.76	0.24	2.71	2.98	15.09	14.04	70.77
Portland	3.11	8.66	5.79	3.71	2.19	0.80	1.76	0.44	1.75	1.72	9.94	10.28	50.15
Rainier	4.90	12.00	6.90	4.91	3.81	1.00	2.43	0.49	2.76	2.23	10.79	15.37	67.59
Seattle	5.25	8.10	4.19	2.20	1.86	1.71	2.01	0.48	2.15	2.71	6.30	8.82	45.78
Vancouver	3.86	9.14	4.76	3.14	2.28	0.75	1.94	0.31	1.92	1.74	10.00	11.13	50.97
1903													
Astoria	14.52	3.18	9.48	6.16	5.44	3.78	0.98	0.96	1.81	7.25	12.45	8.85	74.86
Olympia	11.27	2.80	7.77	3.92	2.16	3.10	0.46	1.18	3.64	4.06	11.72	4.80	56.88
Portland	5.43	1.44	4.29	2.25	1.71	2.00	0.51	0.81	1.13	2.20	10.71	3.14	35.62
Rainier	9.52	2.27	5.90	4.15	2.94	2.85	1.22	2.31	2.50	3.29	9.56	3.61	50.12
Seattle	3.12	1.45	6.10	1.56	2.39	1.55	1.28	0.50	3.18	1.94	7.34	4.14	34.56
Vancouver	5.29	1.84	4.07	2.40	1.71	2.06	0.37	0.56	1.58	2.26	9.34	2.77	34.25
1904													
Astoria	13.30	13.80	13.82	5.22	1.32	2.19	1.99	0.09	0.92	3.57	17.34	15.02	88.67
Olympia	7.88	12.17	9.30	3.64	0.09	1.68	1.79	0.43	0.21	2.33	13.23	8.32	61.67
Portland	5.22	11.08	8.73	2.26	0.59	0.45	0.73	0.20	0.28	2.29	7.40	7.14	46.37
Rainier	7.95	12.79	8.31	4.48	1.66	1.32	1.25	0.27	0.45	2.39	10.43	7.86	59.16
Seattle	5.61	2.76	3.45	1.04	3.37	3.03	0.36	0.44	1.70	4.29	2.68	5.62	34.35
Vancouver	4.46	1.95	4.05	1.54	3.36	2.40	0.24	0.18	2.53	4.15	2.97	5.47	33.30
1905													
Astoria	9.22	6.87	10.89	1.53	6.37	2.52	0.34	1.22	7.38	8.60	5.54	12.15	72.63
Olympia	6.14	4.17	5.12	0.71	2.85	3.18	0.66	0.30	3.33	7.36	3.73	8.88	46.43
Portland	3.66	1.77	5.03	1.71	2.56	2.12	0.12	0.19	2.79	4.73	3.01	6.41	34.10
Rainier	3.60	2.07	5.86	1.57	3.06	2.74	0.22	0.45	2.76	5.73	3.33	6.21	38.60
Seattle	5.61	2.76	3.45	1.04	3.37	3.03	0.36	0.44	1.70	4.29	2.68	5.62	34.35
Vancouver	4.46	1.95	4.05	1.54	3.36	2.40	0.24	0.18	2.53	4.15	2.97	5.47	33.30

Black & Veatch

Longview, Washington

Precipitation in inches, by months, from 1900 to 1922 inclusive (Continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1906													
Astoria	8.91	9.79	3.07	2.94	3.26	4.98	0.22	0.28	8.66	8.67	16.98	14.97	82.73
Olympia	8.57	5.16	1.41	1.41	4.77	3.74	0.30	0.02	5.24	6.33	16.43	10.48	63.86
Portland	5.72	6.76	2.23	2.02	2.00	3.03	T	0.05	2.20	3.43	8.30	7.55	43.29
Rainier	6.09	5.69	2.60	1.51	3.43	4.01	T	0.01	3.28	5.38	11.17	9.31	52.58
Seattle	5.03	4.60	0.89	0.34	2.64	1.97	0.11	0.15	3.31	3.16	7.67	6.80	36.67
Vancouver	4.90	5.90	2.47	1.63	2.41	3.24	T	0.05	2.09	3.25	9.42	6.92	42.38
1907													
Astoria	13.54	13.65	7.82	4.37	2.51	2.67	0.74	0.80	2.92	1.08	10.88	12.93	73.91
Olympia	7.22	5.43	3.24	3.79	0.97	1.50	1.22	1.03	3.79	0.99	10.47	12.03	51.68
Portland	8.23	3.54	3.86	3.57	1.37	1.84	1.19	1.02	1.73	0.93	6.51	9.10	42.89
Rainier	8.03	4.18	3.31	3.69	1.21	2.76	0.92	0.97	2.15	1.71	8.09	11.17	49.19
Seattle	4.18	3.87	1.12	1.54	0.98	0.78	0.71	0.80	3.39	0.67	4.73	6.33	29.10
Vancouver	6.55	4.67	2.67	2.81	1.56	1.80	0.99	1.38	2.17	0.68	5.77	8.81	39.86
1908													
Astoria	8.70	6.80	6.90	3.89	4.36	2.72	0.36	1.22	0.02	4.92	6.08	10.73	56.71
Olympia	6.63	8.00	8.33	4.75	2.68	0.21	0.41	1.28	0.19	1.26	6.75	9.84	53.38
Portland	4.73	2.85	4.39	3.38	4.66	0.67	0.05	1.34	0.23	5.17	3.10	3.80	34.37
Rainier	6.04	4.98	6.96	4.18	4.67	1.54	0.24	1.98	0.27	5.42	5.34	7.34	48.96
Seattle	4.10	4.24	2.54	2.19	3.19	0.15	0.24	0.82	0.23	2.34	4.60	3.61	28.25
Vancouver	4.20	2.80	3.85	3.05	4.31	0.80	0.08	1168	0.16	4.40	3.26	4.18	32.77
1909													
Astoria	12.88	16.84	4.19	0.21	4.91	1.10	2.41	0.68		6.99	13.97	5.24	69.42
Olympia	10.79	10.79	3.02	0.77	2.02	0.77	1.22	0.21	1.14	4.27	19.94	6.30	61.24
Portland	9.29	7.03	2.35	0.89	1.79	0.17	2.26	0.05	0.95	2.01	12.49	4.47	43.75
Rainier	9.38	8.26	2.99	2.25	2.43	0.64	2.58	0.31	1.26	3.47	16.93	5.95	56.45
Seattle	6.90	4.35	1.08	0.77	1.60	0.64	0.35	0.27	1.10	2.86	9.11	2.69	31.72
Vancouver	9.33	6.26	2.10	0.87	1.91	0.14	2.41	0.07	1.41	2.43	12.79	4.52	44.24
1910													
Astoria	14.69	12.72	8.34	5.05	2.87	3.45	0.04	0.58	3.39	8.97	15.85	10.90	86.85
Olympia	10.19	9.17	5.60	3.62	1.67	1.04	0.00	0.05	1.43	8.07	14.41	7.71	62.96
Portland	6.26	6.45	2.25	3.78	1.82	1.61	T	0.13	1.15	3.43	8.24	3.53	38.65
Rainier	7.88	8.82	4.28	3.84	2.63	2.16	T	0.59	1.99	5.02	10.59	5.35	53.15
Seattle	5.08	5.03	1.80	2.41	1.88	0.82	0.01	0.17	1.04	4.02	8.47	3.47	34.20
Vancouver	6.47	5.74	2.17	3.41	2.11	1.20	0.02	0.29	1.34	3.42	8.78	3.59	38.54
1911													
Astoria	10.68	4.36	2.89	3.22	6.88	1.25	0.40	0.72	2.81	3.06	11.91	10.99	59.17
Olympia	6.99	3.70	2.32	1.64	4.09	0.70	0.18	0.22	3.84	1.21	9.89	4.61	39.39
Portland	8.53	3.34	0.63	2.11	3.95	0.87	0.01	0.28	5.19	0.99	2.64	4.74	33.28
Rainier	6.26	4.32	1.59	2.66	4.79	1.55	0.14	0.38	3.06	1.26	8.12	5.25	39.38
Seattle	3.67	1.42	0.88	1.21	2.48	0.44	0.18	0.13	3.27	1.00	3.26	3.75	21.69
Vancouver	7.50	2.90	0.70	1.68	4.08	1.07	0.11	0.76	4.88	1.07	2.28	3.82	30.85
1912													
Astoria	20.90	10.23	3.30	3.53	3.07	4.14	1.23	4.09	2.69	5.21	15.11	12.39	85.89
Olympia	10.95	6.85	2.82	2.68	2.21	2.20	1.63	3.10	2.08	4.47	9.98	10.59	59.56
Portland	8.01	4.85	1.41	2.04	1.89	3.03	0.48	3.39	1.18	3.36	5.80	8.03	43.47
Rainier	11.15	5.93	2.90	2.39	2.51	3.39	1.75	4.88	1.56	4.60	7.07	11.33	59.46
Seattle	4.52	3.11	1.79	1.73	1.64	2.76	1.15	2.48	0.73	3.97	6.82	4.43	35.44
Vancouver	7.98	4.20	0.72	1.85	1.55	3.13	0.88	3.57	1.40	2.76	5.35	6.10	39.49

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Longview, Washington

Precipitation in inches, by months, from 1900 to 1922 inclusive (Continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1913													
Astoria	15.16	2.98	5.74	4.84	3.17	5.33	2.37	0.41	5.98	5.27	12.06	7.96	71.29
Olympia	9.48	1.57	3.20	2.12	2.89	3.24	0.62	0.66	2.83	3.87	9.57	3.61	43.66
Portland	6.25	1.13	4.04	2.94	1.63	4.24	0.24	0.76	2.58	3.62	5.39	3.48	36.30
Rainier	7.31	1.99	4.17	3.23	2.19	3.78	0.98	0.64	3.11	3.91	9.41	3.51	44.23
Seattle	4.89	1.34	1.55	0.83	1.37	1.71	0.73	0.45	2.37	2.00	4.74	2.61	24.59
Vancouver	5.36	1.06	3.30	2.51	1.79	3.49	0.27	0.29	2.41	3.29	5.91	3.68	33.36
1914													
Astoria	22.83	5.95	6.04	4.84	2.37	3.09	0.13	0.12	4.94	10.02	11.26	4.51	76.10
Olympia	16.27	2.97	3.40	2.82	0.94	1.35	(0.07)	(0.70)	3.38	6.68	8.22	2.05	48.85
Portland	11.53	4.19	2.28	3.08	1.22	1.52	0.01	0.01	3.10	3.47	3.70	2.56	36.67
Rainier	14.95	4.34	3.07	4.04	1.69	2.27	0.13	0.06	3.15	4.52	5.53	2.78	46.53
Seattle	9.82	1.93	1.40	3.31	0.74	1.75	0.01	0.01	1.42	4.37	5.28	1.39	31.43
Vancouver	11.22	3.68	2.07	3.22	1.31	1.99	0.02	0	2.81	3.10	3.32	2.41	35.15
1915													
Astoria	11.20	6.97	5.70	4.64	4.96	2.04	2.36	0.06	1.39	7.20	14.72	17.99	79.23
Olympia	4.54	4.09	2.85	2.56	2.70	1.05	1.74	0.03	0.55	1.99	9.71	8.85	40.64
Portland	5.90	3.07	2.15	2.03	2.59	1.47	1.52	0.01	0.53	1.98	11.32	8.73	41.30
Rainier	5.31	3.95	2.85	2.94	3.81	1.14	2.62	0.04	1.01	3.11	10.87	11.86	49.51
Seattle	6.35	2.76	1.72	2.91	1.72	0.40	0.84	0.05	0.65	3.00	5.66	7.77	33.83
Vancouver	6.35	4.80	2.91	3.18	3.19	0.24	0.13		1.35	5.14	10.94	13.04	52.27
1916													
Astoria	10.03	20.20	17.23	4.50	3.63	1.98	7.58	0.45	2.23	2.31	11.13	10.93	92.50
Olympia	6.28	11.60	12.85	3.78	2.48	1.61	2.23	0.07	0.64	2.79	6.54	5.15	56.02
Portland	5.69	7.87	10.57	2.85	2.05	1.83	2.55	0.27	0.71	1.26	6.31	3.81	45.77
Rainier	5.62	7.31	13.61	2.28	3.82	2.51	2.91	0.34	1.63	1.93	5.56	5.40	52.92
Seattle	4.32	6.85	5.45	1.98	1.56	1.82	1.93	0.11	0.70	1.18	4.58	4.13	34.61
Vancouver	4.02	8.34	8.38	2.43	2.02	1.86	3.15	0.19	1.12	0.99	5.38	3.34	41.22
1917													
Astoria	9.63	5.76	10.61	10.73	2.01	4.98	0.47	0.02	4.37	1.25	4.52	(11.70)	66.05
Castle Rock								00	1.99	0.29	4.14	25.56	31.98
Kalama	(10.10)	(7.90)	10.67	10.43	2.10	2.74	0.18	0.02	3.25	0.69	6.13	21.83	76.04
Olympia	5.39	4.77	7.38	6.14	1.20	2.29	T	0.13	2.74	0.27	4.39	19.85	54.55
Portland	2.54	3.32	5.33	5.36	2.31	1.17	0.01	T	1.96	0.03	4.24	14.23	40.50
Rainier	4.99	3.02	7.39	5.21	2.38	2.13	0.14	0.08	2.60	0.84	3.18	19.10	52.06
Seattle	2.02	1.43	2.96	4.48	0.83	3.70	0.09	0.03	1.29	0.16	2.20	9.21	28.90
Vancouver	1.69	2.43	3.89	4.87	1.99	1.30	T	T	2.33	0.10	3.88	11.92	34.34
1918													
Astoria	(12.50)	11.45	9.22	2.93	2.70	0.64	0.67	2.03	0.01	8.18	9.01	11.22	70.56
Castle Rock	8.09	9.67	5.83	1.95	1.84	0.24	0.58	0.78	0.11	6.92	8.10	9.73	53.84
Kalama	9.81	11.53	6.15	2.94	2.31	0.14	1.86	1.62	0.71	7.19	8.45	8.46	61.17
Olympia	5.12												
Portland	4.68	6.77	3.47	1.13	1.38	0.12	1.08	0.31	0.66	4.47	4.30	3.13	31.50
Rainier	8.32	6.87	3.82	2.19	1.93	0.24	0.53	1.55	0.54	5.44	6.91	5.48	43.82
Seattle	2.94	4.81	3.92	0.96	1.19	0.50	1.38	1.12	0.08	3.46	3.81	5.04	29.21
Vancouver	4.86	6.43	3.32	0.76	1.34	0.12	0.74	0.91	0.44	4.95	5.70	3.19	32.76

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Longview, Washington

Precipitation in inches, by months, from 1900 to 1922 inclusive, (Concluded).

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1919													
Astoria	19.36	11.29	10.81	5.52	3.87	1.72	0.31	0.46	3.06	3.52	10.14	(11.70)	81.76
Castle Rock	15.33	8.52	7.51	4.83	5.07	1.38	0.22	0.23	3.47	2.44	7.76	6.51	63.27
Kalama	13.54	12.03	8.96	5.22	4.09	2.22	0.67	0.69	3.75	3.27	9.17	4.01	67.56
Olympia													
Portland	9.09	8.36	4.64	3.60	1.95	0.91	0.23	0.10	3.18	1.43	7.44	4.78	45.70
Rainier	11.44	6.46	5.11	3.97	2.60	1.76	0.26	0.46	2.78	2.58	6.14	4.05	47.61
Seattle	7.95	3.77	1.84	3.20	2.08	5.35	0.22	0.08	2.03	1.59	4.13	4.10	31.34
Vancouver	8.13	6.63	3.09	3.78	3.12	0.89	0.13	0.03	3.79	1.35	6.71	5.13	41.28
1920													
Astoria	8.19	0.65	8.39	7.66	2.01	2.76	0.90	1.76	8.55	12.80	8.58	18.65	80.90
Castle Rock	7.64	0.80	9.68	4.42	2.38	3.49	1.24	2.43	7.70	7.79	7.20	15.19	69.96
Kalama	5.86	0.84	8.86	7.53	1.89	3.81	1.34	3.14	9.31	10.31	7.98	16.56	76.43
Olympia	10.60	0.31	4.05	(3.40)	1.32	2.74	0.99	1.70	3.52	9.10	6.59	11.53	55.85
Portland	4.84	0.16	3.94	4.75	0.91	2.11	1.18	1.25	4.16	3.71	5.84	8.32	41.17
Rainier	4.35	0.58	5.52	4.38	1.62	1.73	1.03	1.28	5.25	5.28	5.35	10.88	47.25
Seattle	3.92	0.34	2.82	3.46	0.96	1.93	1.00	1.15	2.33	4.19	4.42	5.68	32.20
Vancouver	4.09	0.17	3.28	5.03	0.82	2.43	1.36	1.20	3.94	3.70	5.36	6.70	38.08
1921													
Astoria	18.03	14.53	8.88	8.95	2.52	5.08	0.30	1.26	3.73	7.02	15.95	7.45	93.69
Castle Rock	11.79	10.43	7.10	5.18	2.10	2.68	0.02	1.23	4.39	5.80	14.26	8.86	73.75
Kalama	14.81	9.41	8.24	6.47	2.00	3.10	0.07	0.40	4.79	5.41	15.20	6.09	75.72
Olympia	(7.90)	8.26	6.68	3.61	2.29	0.92	0	1.20	2.49	6.83	(10.30)	(9.20)	59.77
Portland	7.82	7.21	4.28	2.26	0.99	1.36		0.30	3.08	2.78	10.04	3.09	43.21
Rainier	10.38	8.46	6.33	4.17	1.98	2.11	0.13	0.68	3.28	3.53	12.36	5.36	58.67
Seattle	5.56	4.82	3.06	1.76	1.93	1.29	0.18	1.61	1.84	3.91	6.60	7.25	38.81
Vancouver	6.64	6.53	4.51	1.56	0.64	1.41	0.03	0.35	3.07	3.01	9.06	2.90	39.71
1922													
Astoria	5.64	5.24	9.94	5.44	5.38	0.53	0	3.59	1.88	6.89	4.08	(11.70)	60.31
Castle Rock	4.74	4.05	9.07	4.83	8.45	0.28	0	2.74	3.87	5.11	2.57	(13.20)	58.91
Kalama	6.55	6.09	11.78	6.36	3.16	0.65	0	3.14	4.07	5.31	3.52	12.08	62.71
Olympia	T	3.28	5.53	2.33	2.55	T	0	(0.70)	1.51	5.19	1.36	(9.20)	31.65
Portland	3.08	3.29	6.57	5.58	3.02	0.14	T	2.06	1.90	4.70	2.94	(5.90)	39.18
Rainier	4.19	4.17	6.30	3.05	1.77	0.31	0	0.33	2.59	4.54	3.48	(7.90)	38.63
Seattle	1.89	1.74	4.45	2.53	1.08	0.03	0	1.17	1.19	2.37	1.45	(5.10)	23.00
Vancouver	2.42	3.62	4.56	2.37	1.23	0.12	0	3.64	1.89	4.91	2.33	(5.80)	32.89

Note:- Figures in parenthesis were averages not reported in the above data and habe been taken as averages over the entire period for which record is given.

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BLACK & VEATCH
CONSULTING ENGINEERS
MUTUAL BUILDING
KANSAS CITY, MO.

December 27, 1923

Mr. Wesley Vandercook, Chief Engineer,
The Long-Bell Lumber Company,
Longview, Washington.

Dear Sir:

Pursuant to your letter of November 30, concerning the disposal of sanitary sewage at Longview, we have analyzed the plans, estimates, and correspondence submitted by you and report herewith our conclusions. We note that your office has decided, after careful consideration of arguments for and against sewage disposal, to meet the requirements of the Washington State Board of Health, and we are therefore proceeding in this report on the theory that sewage disposal is necessary and desirable.

Locating the sewage disposal works and pumping station at Oregon Way and Alder Street meets with our approval unless there is low lying territory between Ditch No. 3 and the Columbia River east and west of Oregon Way, which will not drain by gravity back to this location. In our general sanitary sewer plan as outlined when at Longview, the main trunk sewer on Oregon Way was run as a gravity line to a pumping station location at the Columbia River, because we did not know what territory would be developed near the Columbia River, or how it would be developed, and it was necessary to be able to take care of just as much territory east and west of Oregon Way, by gravity, as possible. If now, you have determined the nature and extent of the development which you will sewer by gravity to this main sewer on Oregon Way, without the necessity of building other pumping plants to handle sewage from small areas which might be served by gravity under the former plan, the location at Alder Street and Oregon Way fully meets our approval, for either a pumping plant discharging to the Columbia River or to Ditch No. 3.

As we view the requirements of the Washington State Board of Health, the matter of sanitary sewage treatment at Longview resolves itself into the clarification of the sewage so it may be readily disinfected, disinfection of the effluent prior to its discharge into waters of the State, and some satisfactory method of disposal of the sludge. This being true, the selection of the type of plant to be used at Longview becomes largely a question of satisfactory treatment and disposal of sludge, with the cost of operation of the plant itself, an item of secondary importance.

The treatment and final disposal of sanitary sewage sludge is one of the most serious problems connected with the general problem of sewage disposal. The treatment of liquid sewage, from which sludge has been settled by any of the five or six recognized types of plants, is a comparatively simple matter, but the treatment of the sludge, in order to produce a stable and inoffensive residue, has been difficult, and sanitary engineers have, for a considerable period of time, been turning their attention to both the theoretical and practical phases of this problem.

The following table* shows volumes and weights of sludge produced by well recognized sewage disposal processes, and it is reproduced herewith because of its direct bearing on the selection of the type of plant to be used at Longview.

Treatment process	Normal volume in gallons of sludge per million gallons of sewage treated	Proportion of Solids in Sludge	Weight in pounds of dry solids in sludge per million gallons of sewage treated
(Col. 1)	(Col. 2)	(Col. 3)	(Col. 4)
Activated sludge	10,000	2.00	1,675
Chemical precipitation	5,000	7.50	3.250
Sedimentation	2,500	5.00	1,060
Septic Tank	500	5.00	220
Imhoff Tank	500	15.00	670
Trickling filter-humus tank	500	7.50	320

* Public Health Bulletin #132 - "Sewage Treatment In The United States" from the office of the Surgeon General.

For the sake of brevity we are dismissing from further consideration all of six types of treatment tabulated above excepting plain sedimentation, which is your design, and Imhoff tank treatment, which we will, later in this report, offer to take the place of plain sedimentation.

Activated sludge treatment is dropped from consideration because of (a) cost of plant (b) cost of operation. Chemical precipitation is eliminated because of (a) cost of plant (b) cost of operation (c) difficulty of handling sludge, because of character and amount. Septic tanks are eliminated because of (a) cost of plant (b) character of effluent, (c) and final disposal of sludge - (not important). Trickling filters are eliminated because of (a) first cost (b) the fact that the sludge disposal problem still remains, (c) not a clarification process.

We will be glad to go further into the details of these matters if your department so desires.

It is our opinion this matter of sludge treatment and disposal is of such serious importance as to cause the rejection of the type of plant outlined by your department. This plant as designed is a plain sedimentation type plant, with the effluent after sedimentation being disinfected by chlorine, prior to discharge into Ditch No. 3. The capacity of the plant as designed is correct, with the exception of the fact that the sewage flow for twenty-four hours is assumed as running off at a uniform rate throughout twenty-four hours. As a matter of fact, for populations up to and including the ultimate capacity of this plant, say approximately 25,000, the sewage flow will practically all take place within sixteen hours.

The settling tanks as designed by you must be operated as plain settling tanks, and provision made to remove sludge each week during the winter months, and from three to five times a week during warm weather. In the event this is not done septic action will be set up in the tank, sludge will be disgorged, and the purpose of settling, defeated.

In plain sedimentation the quantity of wet sludge in normal sanitary sewage may be estimated at (see preceding tabulation) a total of 1,000 cubic feet per day for a population of 25,000. The composition of such sludge is about ninety percent water; it is difficult to dry, highly putrescible, slimy and offensively odorous, which latter quality vitally affects the location of the plant as well as the ease of handling of the sludge itself. There is little doubt that under certain atmospheric conditions, this odor would be noticeable for a mile or more from the plant. Sludge drying may be accomplished by mechanical apparatus, or by exposure to the air, during dry weather, on properly underdrained sand filters. Mechanical drying is to be avoided whenever possible and outdoor drying at regular weekly, or shorter, intervals, for at least six months of the year is impossible at Longview. The plans and estimates submitted by you make no provision for the handling, drying and final disposition of sludge, which are the principal items for consideration in a sedimentation type plant; the quantity to be removed at weekly intervals, on the basis of a population of 25,000, being 7,000 cubic feet of wet sludge, which after drying, leaves approximately 23,000 pounds of dry solids to be disposed of.

Disinfection of the liquid effluent from any type of plant you build will probably be accomplished by means of liquid chlorine. The plans submitted by your department provide for one and three quarter hours "contact" after passage from the basins in which the raw sewage is clarified by settling, and at the outlets of which the chlorine is applied. These contact basins are unnecessary so far as action of chlorine is concerned, and may be omitted without affecting the efficiency of chlorine disinfection. Their elimination will save about 600 cubic yards of the total of approximately 1,380 cubic yards of concrete necessary for the settling and contact basins as designed. The added cost will be for a venturi tube and connections, as detailed later in this report.

In the disinfection of water and sewage it has long been recognized that the action of chlorine disinfectant is practically instantaneous. The question in the case of sewage is merely one of making certain that all suspended matter possible be removed so the chlorine can actually make contact. Kansas State Board of Health experiments on one such disinfecting plant, designed by ourselves, show that beyond the point of application of the chlorine, elaborate contact tanks are unnecessary. This fact has long been recognized by water purification engineers and it is known as a matter of general operation that over-chlorinated water cannot be used effectively for treating other untreated water. The chemistry of disinfection by chlorine may not be generally understood, but the action is as follows:

(a) The liberation of hypochlorous acid by free carbonic acid in the sewage.
(b) Breaking up of hypochlorous acid into oxygen and hydrochloric acid in the presence of easily oxidizable matter in the sewage.
(c) The immediate neutralization of the hydrochloric acid by carbonates and bi-carbonates in the sewage.
(d) The nascent oxygen liberated by the above processes is wholly responsible for the destruction of bacteria and the oxidization of other organic matter present.

Inasmuch as the oxidization process may take place just as freely in an open ditch or conduitas elsewhere, it has been our practice to introduce disinfectant in an outlet pipe from the plant, in the case of sewage, or in the pump suction in the case of water, without considering a contact period. Should your engineering department desire further discussion on this phase of the subject, we shall be glad to furnish a bibliography covering recognized experimental work in connection with this matter, as well as conclusions reached by other engineers and ourselves in the design and operation of such plants.

Our recommendation is that you install a modified Imhoff tank, an outline sketch of which, following other designs by this office, is attached, in place of the sedimentation tanks designed by you. Such a plan will not change the requirements of a pumping station nor of the final disinfection of the liquid effluent by means of liquid chlorine. Either type of plant will produce comparable effluents for the purpose of disinfection and discharge to drainage Ditch No. 3. The character, quantity, and method of drying, and final disposition of sludge, cannot be compared. Sludge can be retained in the Imhoff tank for an indefinite period depending on the size of the sludge compartment. Our preliminary plan provides a sludge capacity of about seven months; in the dry summer season it will be withdrawn from the tank and dried in the open air on sludge drying beds or filters, and the dry sludge will be shoveled up and carted to gardens or low areas to be filled. It will be inoffensive when drawn from the tank, as well as during the drying period. Dry sludge from an Imhoff tank has the odor and consistency of leaf mold and is a valuable fertilizer. The following data, based on a population of 25,000 compares some of the figures concerning sludge from the two types of plant.

	Sedimentation Plant	Imhoff Tanks
Quantity of wet sludge, per day	1,000 cu. ft.	200 cu. ft.
Weight of sludge after drying, per day	2,300 lbs.	2,100 lbs.
Character of sludge	see text	see text
Sludge retention period maximum, for cold weather,	one week	six to eight* months
minimum, in warm weather,	three days	six to eight* months

* Sludge retention period limited only by sludge digestion chamber capacity.

The sewage pumping station required for lifting raw sewage from about elevation -8 to the inlet end of either the sedimentation tank or Imhoff tank, will be of the same design regardless of the tank used. The only screening of sewage required by either type of plant will be by means of bar or cage screens placed between the sewer outlet and the pumps. Such screens should remove solids too large to pass through the pumps. Such solids are to be removed and incinerated. The total quantity of screenings is not large, amounting at most to a few wheelbarrow loads each day. The pumping station should be equipped with at least three motor driven sewage pumps, with impellers designed to take solid matter up to at least one inch in size. In considering operating efficiencies of such pumps, it should be borne in mind that such efficiencies are stated for water, and not sewage tests. Overall efficiencies for sewage pumping, where costs enter into this report, are figured on the basis of an overall efficiency of thirty five percent without consideration of the fact that various equipment will show higher or lower efficiencies under varying operating conditions.

The Imhoff tank shown by the attached sketch, is designed for an average of one and one-half hour retention period in the settling compartment, for a sewage flow of one hundred thirty five gallons per capita from a population of 25,000, all sewage flowing off in sixteen hours. The digestion or sludge chamber is designed to provide two cubic feet per thousand per day for 25,000 people, and is capable of retaining the sludge for a period of from six to eight months. The settling compartment is designed on the basis of providing time for settlement of a given volume of sewage, but the sludge compartment capacity is based on total population, irrespective of the volume of sewage; for ordinarily where there are large flows the concentration is low, but the total sludge will be about the same from an equivalent population whether the total sewage flow be large or small. Criticism of Imhoff tanks has usually been because of foaming. Adequate sludge digestion capacity relieves this condition, and recent installation of mechanical devices on at least two plants designed by this office, have almost completely removed foaming in the gas vents. The operation of such a mechanical device is inexpensive, requiring only a two horse power motor, operating part time, on a plant handling sewage for 25,000 population. Imhoff tank sludge will not have an objectionable odor, either when discharged from the tank, or during the drying process. We have outlined a sludge filter at the plant, on which wet sludge from the Imhoff tank will be discharged by gravity, the liquid drained away from the sludge through the sand filter, collected by an underdrain system, run by gravity back to the pumping station, and repumped with other sewage to the tank. The dry sludge may then be shoveled from the filter bed surface.

The method of chlorine disinfecting treatment we recommend in connection with this plant is the passage of all sewage from the tank through a Venturi tube. Such an arrangement allows sufficient head to automatically control the rate of chlorine feed, insuring uniformity of rate of chlorine feed per million gallons of sewage flow.

The final effluent from either type of plant, discharged to Ditch No. 3, should not, with ordinary velocities and quantity of water in the ditch, create a nuisance by the collection of suspended matter carried over. However, it should be understood that at no time should the flow in this ditch become stagnant nor should it be allowed to create pools of back water at the pumping station at the lower end of the ditch.

When we were at Longview in January of 1923, you advised us that the drainage system of the truck farm property west of Longview proper, involved the building of a drainage system to be used for purposes of subirrigation in dry seasons. We have made no calculations respecting the effect the sewage content of water from Ditch No. 3 would have when so used, for it is impossible at this time to figure the degree of dilution of the sanitary sewage after reaching this ditch. We suggest your department carry on an investigation along this line. It is essential that treatment of manufacturing wastes, if any, be carefully considered before deciding to put them through either of the plants covered by this report, or before discharging them untreated into Ditch No. 3. Wastes from creameries for example, require special treatment before being discharged into either plain sedimentation or Imhoff tank plants. Tannery wastes should by no means be allowed to run in the open ditches through Longview because of the danger from anthrax.

We have tentatively placed the Imhoff tank so the sewage elevation is at plus 30 instead of 21, as in the case of your design. This is a maximum elevation and can probably be reduced after an examination of ground conditions, because there is no reason other than cost of excavation, for holding the structure at the elevation indicated. The cost of pumping, on the basis of three cents per K.W. hour, will be decreased about $300.00 per year for each foot of decreased pumping head. As the two plants now stand with nine feet difference in elevation of the sewage surfaces, it will cost $2,700.00 per year more to pump to our design. Costs of pump operation, however, should not be allowed to confuse the facts as regards costs of sludge treatment and disposal, for, as we have heretofore stated, it is on this subject of sludge, that we condemn the sedimentation type of plant as being wholly unsuited to your particular needs.

The following approximate estimate of cost is not so important as is the approximate estimate of quantities. Your department can no doubt apply unit costs developed by contracts at Longview, to our estimate of quantities, which will be more accurate than those used by us.

Preliminary Estimate

Imhoff Tank:

8,000 cu. yds. earth excavation in & about tank	@ $ 0.40	$3,200.00	
1,075 cu. yds. reinforced concrete	35.00	37,625.00	
Total Cost of Imhoff Tank			40,825.00

Preliminary Estimate (Cont'd)

Amount Brought Forward			$40,825.00
Sludge Filter: No additional excavation if placed on embankment.			
100 cu.yds. concrete	@ $18.00	$1,800.00	
360 cu. yds. filter sand	4.00	1,440.00	
600 cu. yds. filter rock	4.00	2,400.00	
1,104 lin. ft. 6" sewer pipe (vit)	.30	331.20	
224 lin. ft. 8" sewer pipe "	.45	100.80	
120 lin. ft.12" sewer pipe "	1.10	132.00	
24 pcs. 8"x6" tees (vit)	1.50	36.00	
Total cost of Sludge Filter without concrete bottom		$6,240.00	
If 4" concrete bottom is used in sludge filter add 12,500 sq. ft. paving	.20	$2,500.00	
		$8,740.00	
Chlorinator House and Equipment		$5,000.00	
C. I. Pipe and Specials and Valves			
44 tons C. I. pipe	@ 100.00	$4,400.00	
11 tons C. I. special castings	180.00	1,980.00	
8 - 6" Valves	35.00	280.00	
12 - 8" "	45.00	540.00	
		$7,200.00	
Grand Total, cost of entire disposal plant (Pumping Plant not included), but including concrete bottom in sludge filter		$61,765.00	
Plus 10% for overhead, contingencies		6,176.50	
Total Cost...............		$67,941.50	

We have endeavored in this report to eliminate all superfluous explanation concerning matters of minor importance, and which may be considered to better advantage at a later date. It is possible that in so doing we have failed to make certain points clear, and we are anxious to go fully into any questions suggested, and not fully explained or answered by this report.

Yours very truly,

BLACK & VEATCH

By E B Black
(E. B. Black)